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IRON and STEEL ENGINEER

FUEL — ELECTRICITY — MACHINERY — METHODS

EMPIRE BUILDING, PITTSBURGH, PA.

To Educate the Engineer in Industry

SEPTEMBER, 1924

Containing the Proceedings of the A.I.&S.E.E.

Iron and Steel Exposition

Developments in Electric Maintenance Shop Practice

By A. C. CUMMINS

Electrical Engineer, Carnegie Steel Company, Duquesne, Pa.

Power in the Iron and Steel Industry

By BARTON R. SHOVER

Consulting Engineer, Pittsburgh, Pa.

The Slagging Producer in Steel Works

By K. HUESSENER

President, American Heat Economy Bureau, Fittsburgh, Pa.

Crane Hoist Travel Limit Devices

By WALTER GREENWOOD

Safety Engineer, Carnegie Steel Company, Youngstown, Ohio

Machine Tools and Their Auxiliaries in the Steel Mills

By J. F. KELLY

Business Manager, A. I. & S. E. E., Pittsburgh, Pa.

Combustion Control

By E. G. BAILEY

President, Bailey Meter Company, Cleveland, Ohio

Electric Furnace Installation

By R. S. SAWDEY

Electrical Superintendent, Van Dorn Iron Works, Cleveland, Ohio

Report of Electric Furnace Committee for 1924

By GEORGE H. SCHAEFFER

Chairman, Electrical Engineer, Carpenter Steel Company, Reading, Pa.

Electric Melting Furnaces

By J. A. SEEDE

Engineer, General Electric Company, Schenectady, N. Y.

Medium Temperature Furnace Installations

By C. F. CONE

Engineer, The Hagan Corporation, Pittsburgh, Pa.

Medium and Low Temperature Applications

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Manager Steel Mill Division, Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa.

Electric Heating With Special Reference to Central Stations

By E. D. SIBLEY

Engineer, Metropolitan Edison Company, Reading, Pa.

Adjustable Speed Drives for Rolling Mills

By L. A. UMANSKY

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The Steel Industry and the Electric Utilities

By MERRIL SKINNER

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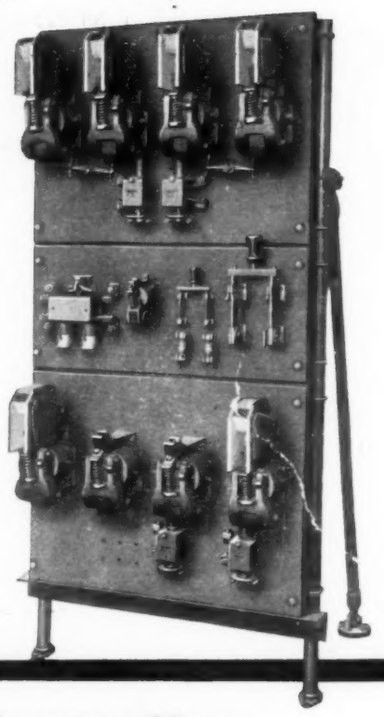

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J. F. KELLY, Editor

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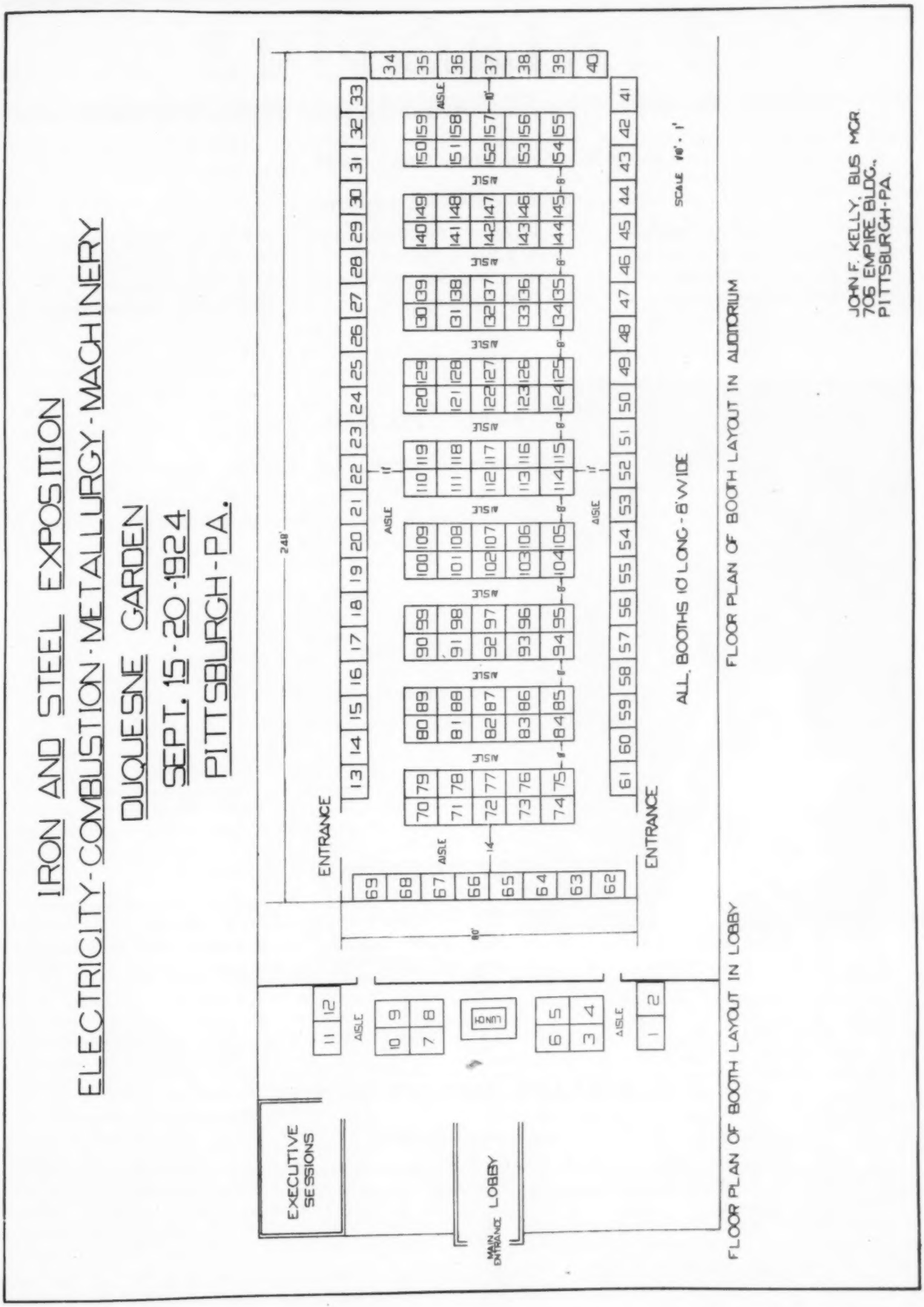
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EDITORIALS

A. I. & S. E. E. ANNUAL CONVENTION

By R. S. SHOEMAKER*

THE Nineteenth Annual Convention and Exposition of the A. I. & S. E. E. very appropriately will be held this year in the Duquesne Gardens in the City of Pittsburgh; very appropriately, so we think, because as an engineering society devoted solely to the interests of the steel industry, Pittsburgh, the world's greatest steel center, is also our home town and we fell that no better place could be found in which to demonstrate to the industry at large and our own employers in particular the splendid progress made by this Association during the past 18 years.

We feel that this year's work has been very beneficial to our industry and to our membership in many ways, notable among which should be mentioned the very successful fuel-saving conference held in Pittsburgh April second and third by our Combustion Engineering Section, which was attended by the leading Combustion Engineers of the steel and allied industries of the country, at which time many vital problems related to the more efficient utilization of our fuel supplies were discussed.

January of this year witnessed the publication of our monthly magazine, The Iron & Steel Engineer, which has in this short time gained a most enviable position in the trade magazine field and is fast being recognized as the authority on all subjects pertaining to the practical application and utilization of fuel, electricity, machinery and methods as applied to the modern steel plant.

Our branch sections, of which we have five, located at Philadelphia, Birmingham, Cleveland, Chicago and Pittsburgh, have this year been most progressively active in having presented before them papers by the leading engineers of the country covering the most modern and vital subjects, which have been of intense interest and benefit to our managements as well as to our membership.

Standardization of electrical and mechanical equipment of our plants has always been considered of very great importance and we have had for many years committees working to this end on various classes of steel mill apparatus with considerable success, but there yet remains a vast amount of work to be done in this field. We now have our standard specifications for heavy duty cranes, general specification for a.c. main roll drives, mill type motors, etc., but we have always felt that our committees have not been able to freely devote sufficient time to this work and that our companies have not been sufficiently informed as to the mutual benefits to be derived by the steel companies, the manufacturers and the association membership. As a result of this feeling we have during the year communicated with the managements of practically all of the steel companies, explaining in detail that our work along this line is in every way constructive and will not hamper or limit the manufacturers in developing their apparatus to the most efficient point possible, and requesting that they appoint one or more members of their organization to work with our standards committee chairmen, we have had splendid response from the steel companies and are now in better shape to go forward with this work with committees which have the full backing and understanding of their employers.

At our national convention, held at Milwaukee in 1912, the National Safety Council was born and the slogan **"Safety First"** was coined, thus marking the first organized safety movement in our mills as well as all other American industry. While statistics most emphatically indicate a tremendous reduction in the number of industrial accidents during the last 12 years, there is yet a great deal of work to be done, particularly of an educational nature, and it is my earnest hope that this, our nineteenth convention, will once more be responsible for a constructive safety movement which will be in line with our policy of expansion and will afford the safety engineers of our industry a medium through which they may better exchange ideas and have the benefits of a national organization interested only in the problems of iron and steel.

R. S. SHOEMAKER, President A. I. & S. E. E.

Looking ahead, our future as an engineering association looks particularly bright, we are on a sound financial footing, our membership generally is enthusiastic and increasing in numbers; especially so is

*President A. I. & S. E. E.; Superintendent of Maintenance, American Rolling Mill Company, Middletown, Ohio.

this true of our foreign enrollment, which indicates that we are more and more each year becoming the exchange medium for progressive engineering within the steel industry of the entire world.

The space alloted me does not permit of my saying much about our future plans, but I cannot let this opportunity pass without expressing the hope that the rank and file of our association will in the future put forth the same effort and show the same spirit of helpfulness toward their national officers and directors, and loyalty to their association as they have shown during the past year—then I know the welfare of the A. I. & S. E. E. will be assured.

WHAT OF THE FUTURE?

By F. W. CRAMER*

THERE was an editorial in one of the papers some few days ago that drew a striking comparison of the swiftness of developments of the present age with those of past ages. In order to bring the picture within the conception of the average man, it assumed as a base figure the "age of man" as 50 years. Then, by comparison, it was found that all our real electrical developments have come within the last two or three days, and bringing the picture more closely home to the steel industry, our large main roll drives are only a day old.

How rapid this development of our main roll drives has been can be brought forcibly home by going back over our yearly proceedings, and discovering that our association, though young in years, is older than the oldest main roll drive. Each volume unfolds a new story, a new idea is brought forward, probably against a lot of adverse criticism by some staunch pioneer who had the courage to stand by his convictions, and another type of mill is electrified and put into operation. Sometimes we think the steel industry has been skeptical, and we might even say backward in adopting these new developments — but in reality, when a comparison is made with the battle the steam engine had to replace the hand power and the water wheel, the time is relatively short. Starting just about 15 years ago, as a novelty, main drive electrification has been developed and accepted, and now surpasses its old rival—steam.

At present, we are going through another cycle—a battle between the types of these motor drives — which makes it appear as if the wheels of progress have made a complete revolution and are back to the starting point for a new turn. Years and years ago, in this age of electricity, the d.c. motor was developed and brought into use, and served faithfully on many types of installations. Then as the applications called for larger and larger motors, its newer and formidable rival the a.c. wound rotor induction motor began to get recognition and replace the larger d.c. drives until the reversing blooming mill or plate mill motors were about the only large d.c. drives left. The industry, however, needed a variation in speed for several types of mills that the wound rotor induction motor in itself could not give, and in addition, the question of efficiencies and low power factors of this type of motor were becoming more and more important, which caused the motor builders to seek and search for new ideas to meet with the demands. The Kraemer system, Scheribus sets, and the Frequency converter systems were all brought forward as solutions to these demands. All three of these are good drives, as the hundreds of installations will bear out, but the complications in control and the multiplicity of apparatus needed for speed variations kept a shadow of doubt hovering over the steel mill electrical man as to whether the best drive had yet been developed. In the midst of all this, first one electrical superintendent and then another began to believe that perhaps an old reliable friend had been spurned too quickly, and that with a little care and development it could be brought back into its old place. As a result of this, we find that the d.c. main roll drive has, within the past year, re-established itself as a formidable rival to the variable speed sets. It had, however, to find an ally in the synchronous motor driven MG set, in order to put itself across, and in combination with this set, the simple control needed, the high efficiency and the wonderful speed variation that could be obtained, rapidly established the d.c. motor as an ideal installation where speed variation in main roll drives was needed.

This ally we have spoken of, the synchronous motor, seems to be like a neglected child, and has had a hard fight to keep a place on the wheel, yet its possibilities are legion. The old criticism "you have too little starting torque" is hard to live down, but it has found some friends that developed a super-synchronous motor, and other friends who brought out the magnetic clutch, and these have eliminated this weakness. Where a constant speed drive is needed, this neglected line of motors is fast finding a place of its own. A simple control, a good power factor, a cheaper motor where direct connection and slow speed are needed are what it offers—all it needs to be put across is some staunch pioneers who will give it a chance.

We have spoken of these rapid changes of main roll drives and their battle to replace steam, and have given the motors the credit—but who made it possible for the motors to get a chance to make good—who has been the super-salesman that put the deal across? The answer to this can be found in the yearly proceedings of the A. I. & S. E. E. No company or individual was big enough — it required the cooperation of a large number of men, and the story of the pioneers who founded this organization, their fight for recognition of the electrical department, the discussions and criticisms at the meetings, and of the new developments year after year, is a story that will go down in history as the reason for the replacing of the steam drives with motors.

And what can we expect of the future? Who is willing to hazard a guess? We know that mill after mill will replace its steam engine with a motor drive. We can expect developments in the types of drive and in new applications, in fact it will only be a few years until the smelting and reducing processes of the steel industry will have reached such a stage of development in existing practice that, in order to further improve operation they will be calling for the more extensive use of the electric furnace to aid in the refinement of the ores, and thus the expansion of the electrical department will continue until it becomes the all important division in the manufacture of steel.

We also know that there are bound to be great developments in the source of this power — the steam

*Assistant Electrical Superintendent, Bethlehem Steel Company, Johnstown, Pa.

turbine and the hydro-electric plant, and that the dream of a great super-power system will some day be realized. Certain developments, during the past two years, point out that a new type of friendship between the large public service companies and the steel mills is about to be established, and the age old debates "purchased vs. home-made power, or 25 vs. 60 cycles" will be revived to be discussed and settled in a business like way. But whatever the future may bring, the A. I. & S. E. E. will serve as the melting pot, the guide and counsel where these questions can be thrashed out among friends, and the proceedings will add chapter after chapter in this interesting story in the years to come.

You owe it to your company, and your company owes it to you that a common bond be established between yourself and the association. We are no longer fighting for recognition, but are firmly established. The papers presented at the meetings are recorded as authorities on the subjects, in fact the power of the association is so great that it almost controls the destiny of the steel mill electrical applications. Our convention exhibits have grown so fast that it is difficult to find a building that will house them, and space is now at a premium instead of being an effort to sell, showing the high place we occupy in the minds of the manufacturers.

You will find that the electrical development of the steel industry and the Association of Iron & Steel Electrical Engineers are bound hand and foot, and that the more active part that you take in the association, the greater will be your part in this development, and as the story of this progress is recorded, year after year, your part in the work will be preserved for the coming generations.

DEVELOPMENTS IN THE ACTIVITY OF THE A. I. & S. E. E.

By A. C. CUMMINS*

IN considering the trend of the activities of the Association of Iron and Steel Electrical Engineers, it is not possible to avoid the conclusion that the field of effort of this Association has greatly broadened during the past few years. An examination of subjects recently discussed under its auspices immediately places it under the classification of a general steel mill engineers' society rather than an organization of engineers whose meetings deal exclusively with the discussion of electrical engineering problems.

Further consideration of the cause of this enlargement of activity leads to the conclusion that the Association has had no choice in the matter of determining this policy. The enlarged engineering responsibilities of its membership demanded a broadening of the field of the Association if it wished to continue to give service. So rapidly has the use of electricity in the steel industry progressed that every mill improvement now entails an extensive study of the various applications on which the use of electricity may be advantageously adopted. The steel mill electrical engineer is now required to be thoroughly familiar with general steel mill engineering practices in order that he may ably supervise the application of electric drive, and obtain the maximum advantage to be gained by such applications. Thus the demand for broader engineering information has been created and in filling this demand the Association has found it necessary to enlarge the scope of its activities or else fail to live up to the well merited tradition of service to its membership.

The present year has witnessed two outstanding developments in what might be termed "servicing the membership." The first of these has been the change in size and character of the monthly publication. In enlarging the size, the Association has followed the policy of other engineering periodicals and the same mechanical advantages in presenting the subject matter have been secured. There is a marked improvement in the subject matter presented and in the more general nature of its enginering interest. The more liberal dimensions permit the publication of many valuable papers presented at section meetings which hitherto could not be printed on account of lack of space.

In the future it may develop that contributions to the monthly magazine will be accepted which cannot be worked into meeting programs, thus giving the membership additional information on subjects other than those actually discussed in general or section meetings. It is recognized, however, that such practice is open to objection, that great care must be used in selecting papers published without discussion in order to avoid the possibility of impairing the excellent reputation for accuracy now possessed by the "Proceedings."

The second outstanding development of the past year has been the holding of the First Fuel Savings Conference. Many of our members feel that a steel mill electrical engineer must be fully posted on the advances made in the efficient utilization of fuel. For a number of years it has been the custom to devote a day of the Annual Convention to the discussion of the fuel saving problem. At the close of the last Annual Convention at Buffalo it was decided that the time was not sufficient and that a two or three day special spring meeting devoted to the discussion of fuel savings should be inaugurated. Accordingly the First Fuel Savings Conference was held in Pittsburgh in April, 1924. This conference was unusually well attended and the interest displayed on the part of those present indicated a necessity for such a meeting. Such conferences fill a demand that is not covered by any other engineering society and will be continued.

As to future development in the Association's activities no one can do more than surmise. When it is recalled that the steel mill electrical engineer less than 30 years ago was either caring for a few lights or adjusting brushes on a generator, while now his advice is sought in nearly every steel mill engineering problem, and that this Association has always filled the demand of its membership for development, it can be said with conservatism that the future of this Society will reflect the development of the utilization of electricity in the steel industry and the importance of the steel mill electrical engineer. Those who have had the vision and the determination to place the use of electricity in the steel industry in the high position it now possesses as a means of doing work will not cease their activity at the present stage of its development, nor will the research engineers or the designing engineers cease in the improvement of the means offered the steel mill engineer to further the use of electricity. Therefore the future develop-

*Electrical Supt., Carnegie Steel Company, Duquesne, Pa.

ment of the Association must be a continually broadening one until it eventually must become an organization for all classes of steel mill engineers at or before the time when the steel industry becomes 100 per cent electrified.

As surely as the use of electricity in the steel industry is on the threshold of still greater development, the steel mill electrical engineer is on the way to greater recognition. It is the duty of the Association to aid him in his quest for further development. How will it do it? It must act as an educational medium for continued engineering information, an advertising agent to place himself before his public and enable him to sell himself, and finally it must urge that in his enthusiasm for the engineering specialty that is his selected profession, he must never be carried beyond the ethical standards of the engineering profession.

THE VALUE OF CONVENTIONS

By A. J. STANDING*

CONVENTIONS, as the name implies, are gatherings of people who are called together to accomplish, by means of unity of purpose, certain constructive results that could not otherwise be achieved. After all, conventions are made up of individuals and, therefore, the sucess of any convention, both from the standpoint of its accomplishments as a convention as well as from the standpoint of individual gain, must be measured in the final analysis in terms of individual effort. In other words, a convention is what

A. J. STANDING, Chairman,
Banquet Committee A. I. & S. E. E.

the individuals make it, and each attending member gains only in proportion to the effort he exerts to derive benefit from the convention.

The most obvious service any individual can render in behalf of our convention is to attend the various technical sessions and show interest in the industrial exhibits; by so doing he gives the support of his presence to those who strive to make all the features a success.

The conventions of our A. I. & S. E. E. have a fourfold value to those accredited representatives of steel plant electrical departments who attend with the object of getting the greatest possible return for the companies they represent on the money invested in sending them to these conventions.

First, and logically so, is the direct benefit gained by hearing the technical papers read and taking part in the discussion of such papers and reports as are directly of interest to us.

Second is the benefit to be gained from close inspection and discussion of the many interesting and profitable exhibits and actual demonstrations that have become such a prominent part of our conventions. Information gained by actual observation is so much more readily retained.

Third, I feel that the association with men in similar lines of activity, the questions and answers brought up in the many private discussions, are all a very vital part of the actual assimilated knowledge one can take away from our conventions.

Fourth, I place the value of acquaintanceship and sociability fostered among officers, members and associates as being of inestimable value in broadening a man's outlook and his knowledge of the personnel of the electrical end of the steel industry as a whole. Through the friendships begun at our convention there grows a feeling of fraternity that can be counted on in almost any situation that may arise in the actual operation of our various departments and is being more and more used as a medium of exchange of ideas helpful to each other.

I know of no other Association whose conventions are fruitful of more that is of actual lasting value to its members than are our own, provided, of course, we each do our share toward making each feature a success.

There is one other point to be borne in mind, and that is the realization we should all have that when we are assembled in convention we are always the responsible representatives of various steel plants, and the conduct of our entire convention is judged by industry at large in that light. It behooves us all, therefore, to keep the name and fame of the convention of the Association of Iron and Steel Electrical Engineers above reproach.

*Electrical Superintendent, Bethlehem Steel Company, Saucon Plant, Bethlehem, Pa.

WHY ELECTRIFICATION OF MILL DRIVES IS ECONOMICAL

By S. S. WALES*

THE uses of the electric motor today covers a much wider range than its most partisan advocates hoped for when it first entered the mechanical world as a substitute for the earlier devices for distributing power.

The wizard of the electrical fraternity, Thomas A. Edison, at the time he introduced the incandescent lamp, proposed running the entire surface car system of New York City, as it then existed, by electric motor, but advanced as that thought was, it has been surpassed in reality by the wonderful development of the electric locomotive, which is capable of doing the work of three powerful steam engines on the heavy grades in the Rocky Mountains.

*Electrical Engineer, Carnegie Steel Company, Pittsburgh, Pa.

Thomas McDonald, formerly general manager of one of the large steel plants of the country, in 1896 while building a mill in which all auxiliaries were electrically driven, suggested motor driven main rolls for non-reversing mills, but even his dream has been surpassed by the modern reversing blooming mill and continuous mill with their controlling, limiting and protective devices which almost appear to think for themselves.

While a few men of vision and imagination were looking forward and predicting a wonderful future for this new tool that electricity had put into their hands, it is fair to ask what basic reason gave its present supremacy to the electric motor and why it so

S. S. WALES, Director A. I. & S. E. E.

successfully supersedes other power producing units even for main roll drives, and it is interesting to find that this basis is not really electrical.

Sentiment has had little to do with the rapid advance of electric power production, distribution and use in the mill, and to some extent the art has developed backwards, that is from the motor through the distribution system, back to production equipment in reverse order to its discovery. While now resting on the firm foundation of saving in cost over other methods and carrying the two advantages of safety and convenience, it was very fortunate for the infant science that there were steam and hydraulic applications in the mills, where efficiency need not be considered, and to which electric power was admirably adapted even in its crude form.

Steel mill electric power development began about 1892 with the motorizing of pass and runout tables on some old type hand served mills, and by the introduction of electric overhead traveling cranes for roll changing. The electric cranes, charging machines and pass tables immediately took their places in the mill and, with few ver yminor exceptions, superseded all other methods of lifting and transferring material, purely on the ground of ease of transmission of power from a fixed to a moving point. Here efficiency did not enter the question very largely, as compared with convenience.

The fixed motors, running roller tables, etc., had only efficiency to stand on, but the steam consumed by the small hoisting engines then used and the condensation losses in the long small steam lines, gave ample margin for the motor to show an advantage.

At that time power was generated by units of which the 200-hp., belted, 250-volt, d.c. generator was a fair average, the prime movers being single cylinder, simple, non-condensing, slide valve engines, using steam at about 100-lb. gauge pressure. The over-all efficiency of these units could not have exceeded 2½ per cent or 400 lbs. of steam per kwh. After the power had been produced with this tremendous waste, it was transmitted for a distance of from 500 to 1,000 ft. with line losses based on 10 per cent to 20 per cent drop at normal load, peaks not considered, and 60-deg. copper temperature to motors probably averaging 75 per cent efficiency, and strange as it may seem, the first radical improvements in the whole system appeared in the motors. In rapid succession the open type double reduction motor was followed by the open type single reduction, the semi-enclosed single reduction, the wholly enclosed and then the special mill type motor, which was the first concession made by the electrical manufacturers and designers to the steel industry.

During the motor development, transmission lines had been extending until the size of copper and first cost had become a considerable item, so the next improvement followed back from the motor to the line. Slow speed steam engines with large alternating generators were installed, with slightly improved efficiency over the early d.c. equipments, and power was carried at 6600 volts a.c. to the center of consumption, where it was transformed to 250-volt d.c. for use by means of static transformers and rotary converters, which is substantially the method employed today, except that the high speed motor generator set, taking 6600 volts at the a.c. end, has largely superseded the rotary converter due to flexibility and its ability to correct low power factor.

For a long time the competition between the electric motor and other forms of power users was confined to small units and to places inaccessible to steam engines so that it was only when a daring attack was made on an actual electrical mill drive, using d.c. generation, transmission and main roll motor, that the steam drive developed its real strength, which lay in the fact that the central station generating units could not be of appreciably larger size or higher efficiency than the engine that would be required to run the mill direct.

In estimating the economies of such equipment, the engineer was confronted with additional losses, instead of savings, which no amount of "convenience" or "safety" could overrule, and it was only when the electrical industry produced the steam turbine generator that the complete electrification of the rolling mill became an economic possibility. So the final step in the backward line of progress was taken, and the reciprocating steam engine was in full retreat before the victorious motor, except for a rear guard action set up by the uniflow engine, which did not develop the strength its friends expected.

It appears, then, that the basic foundation of the success of the electric motor in replacing steam engines in power development in steel mills is not due to the increase in the power, reliability and efficiency of the motor itself, or in its transmission system, but principally to a radical improvement in the method of using steam itself by means of the turbine, which is more perfectly adapted in speed and construction to driving electric generators than to direct connection to the machinery of the mill.

In some favored sections, where large water powers are available, this will not hold good, but where fuel is the source of power then the turbo-generator must stand as the strongest ally of electric power users. So, with all his pride in the wonderful progress in electrification, the electrical engineer must bow to the steam engineer, who has defeated himself.

Under average conditions and with up-to-date transmission lines and motors, one hp. engine can be delivered to the roll necks of a non-reversing mill by the electric route, using modern compound condensing engines for 2.47 lbs. of coal at the boilers, as against 2.19 lbs. of coal with the same engine direct connected to the mill, including line losses, or an increase of coal consumption of about 13 per cent, whereas with the same electric route, using steam turbine generated power, 1 hp. can be delivered to the rolls for 1.53 lbs. of coal, or a decrease in coal consumption of about 30 per cent over the direct connected roll engine, due entirely to the advantage of the turbo-generator over the engine-driven generator.

COMBUSTION AND FUEL ECONOMY

By W. P. CHANDLER*

THE fuel bill of the steel industry is the greatest raw material cost which has to be met. During the last decade the bill has been climbing by leaps and bounds and it is little wonder that combustion, the process consuming this raw material, has been receiving particular attention. In the field of electric power generation the demand for economical use of fuel is even more pronounced, since it is the largest single item of expense, and it is in this field that we see the greatest economies being obtained.

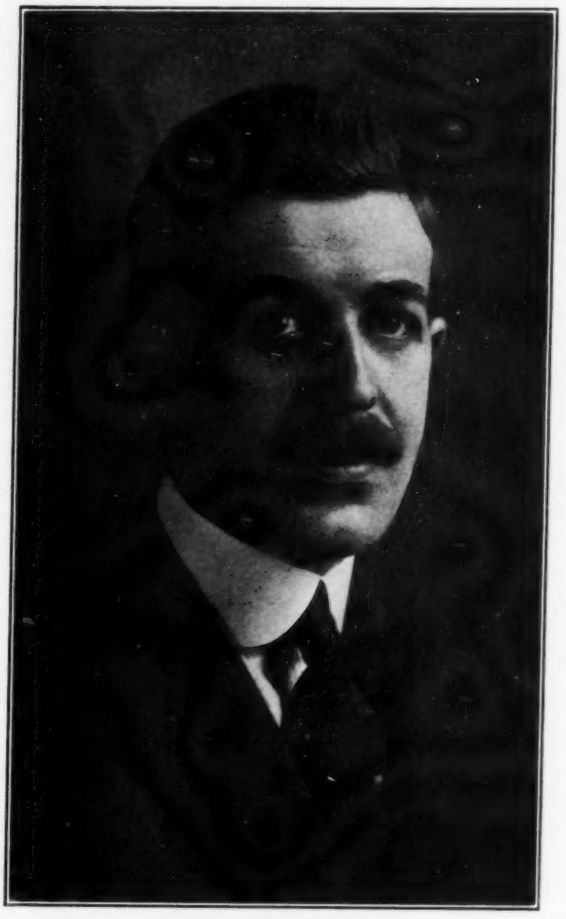
In existing plants the economies are usually brought about by the installation of accessory equipment, such as draft regulation, which will produce more nearly perfect combustion, or by making certain changes in stoker or burner design so that a more intimate mixture of fuel and air will take place. Very great economies can also be obtained by improvements in the generation, transportation and utilization of the steam, the intermediate medium between the fuel and the electric power, and while not strictly in the combustion field it usually falls under the same supervision.

The really large economies, however, are obtained by replacing old equipment with that of recent improved design. This normally requires the expenditure of large sums of money and naturally is much slower of accomplishment.

The boiler of 20 years ago might give 60 per cent efficiency if the firemen were both careful and skillful, but usually the practice was considerably under this figure.

As a comparison, tests conducted at central stations of recent design have shown efficiencies well over 90 per cent for the combined steam-generating equipment.

This improvement in the utilization of fuel in the power houses of the country has been reflected in the government's reports, which show that in the last four years the number of kwh. produced per ton of coal has jumped from 625 to 835, a gain of 33 1-3 per cent.



W. P. CHANDLER, Secretary,
Combustion Engineering Section A. I. & S. E. E.

The supervision of combustion in a steel mill, however, extends far beyond the boilers of the power-generating system. Each department of the plant requires furnaces designed especially for its needs. The fuel best suited to the purpose, or most advantageously obtained, must be supplied in the proper amount and so as to produce the proper working temperature for the process. The heat in the products of combustion leaving the main body of the furnace must be reclaimed as completely as possible, in order to insure the lowest possible fuel consumption.

The blast furnace departments at the present time are probably leading in the matter of fuel economy. The gases leaving the top of the furnace are consumed under boilers or in hot blast stoves or internal combustion engines. The economies obtained in recent boiler installations show exceptionally low losses of

(Concluded on Page XXX)

*Fuel and Experimental Engineer, Carnegie Steel Company, Duquesne, Pa.

Official Program of
Association *of* Iron *and* Steel Electrical Engineers
IRON *and* STEEL EXPOSITION

TECHNICAL SESSIONS
Duquesne Garden, Pittsburgh, Pa.

TUESDAY — 9:30 A. M.

Adjustable Speed Sets for Rolling Mills.
By L. A. Umansky, General Electric Company, Schenectady, N. Y.

11:00 A. M.

Combustion Control.
By E. G. Bailey, Bailey Meter Company, Cleveland, Ohio.

WEDNESDAY
ELECTRIC HEATING FURNACE DAY

9:30 A. M.

Medium and Low Temperature Applications.
By E. A. Hurme, Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa.

10:00 A. M.

Medium Temperature Furnace Installations.
By C. F. Cone, The Hagen Corporation, Pittsburgh, Pa.

10:30 A. M.

Electric Melting Furnaces.
By J. A. Seede, General Electric Company, Schenectady, N. Y.

11:00 A. M.

Electric Heating With Special Reference to Central Stations.
By E. D. Sibley, Metropolitan Edison Company, Reading, Pa.

11:30 A. M.

Electric Furnace Installations at the Van Dorn Iron Works.
By R. S. Sawdey, Van Dorn Iron Works, Cleveland, Ohio.

THURSDAY — 9:30 A. M.

Developments In Electric Repair Shop Practice.
By A. C. Cummins, Carnegie Steel Company, Duquesne, Pa.

10:30 A. M.

Crane Hoists Travel Limit Devices.
By Walter Greenwood, Carnegie Steel Company, Youngstown, Ohio.

11:00 A. M.

The Slagging Producer in Steel Works.
By H. K. Huessener, American Heat Economy Bureau, Pittsburgh, Pa.

12:00 A. M.

Machine Tools and Their Auxiliaries.
By John F. Kelly, A. I. & S. E. E., Pittsburgh, Pa.

FRIDAY
CENTRAL STATION DAY

9:30 A. M.

The Steel Industry and the Electric Utilities.
By Merrill Skinner, Duuesne Light Company, Pittsburgh, Pa., and F. D. Mahoney, West Penn Power Company, Pittsburgh, Pa.

Power In the Iron and Steel Industry In America.
By Barton R. Shover, Oliver Building, Pittsburgh, Pa.

Views of
PITTSBURGH
where
IRON and STEEL
EXPOSITION
will be held

W. A. MAGEE
Mayor

H. E. SPEAKER
Secretary

CITY OF PITTSBURGH
PENNSYLVANIA

September 1st, 1924.

Association of Iron and Steel Electrical Engineers,
Pittsburgh, Pa.

Gentlemen:

I take great pleasure in welcoming the delegates of your Convention to our city. The engineers of your Association engaged in the application of electricity in all the many and various phases in which iron and steel are used are filling a very important niche in the development of our city and nation. You gentlemen are the advance guards of progress and as such you are indeed welcome to Pittsburgh.

Iron and steel have brought great wealth to Pittsburgh and made this one of the industrial centers of the world. The almost universal use of iron and steel entering largely into everything that is built, constructed and used, and the application of electricity in thousands of different ways, are two of the outstanding factors of this marvelous age.

Pittsburgh is indeed grateful to and proud of its engineers who have been in a large degree responsible for giving work to thousands of people and for bringing a fair share of the wealth of the world to our doors and homes. Our great iron and steel plants have challenged the admiration of the world, and next to the names of Edison and Marconi no other is so important in the electrical sphere as that of George Westinghouse.

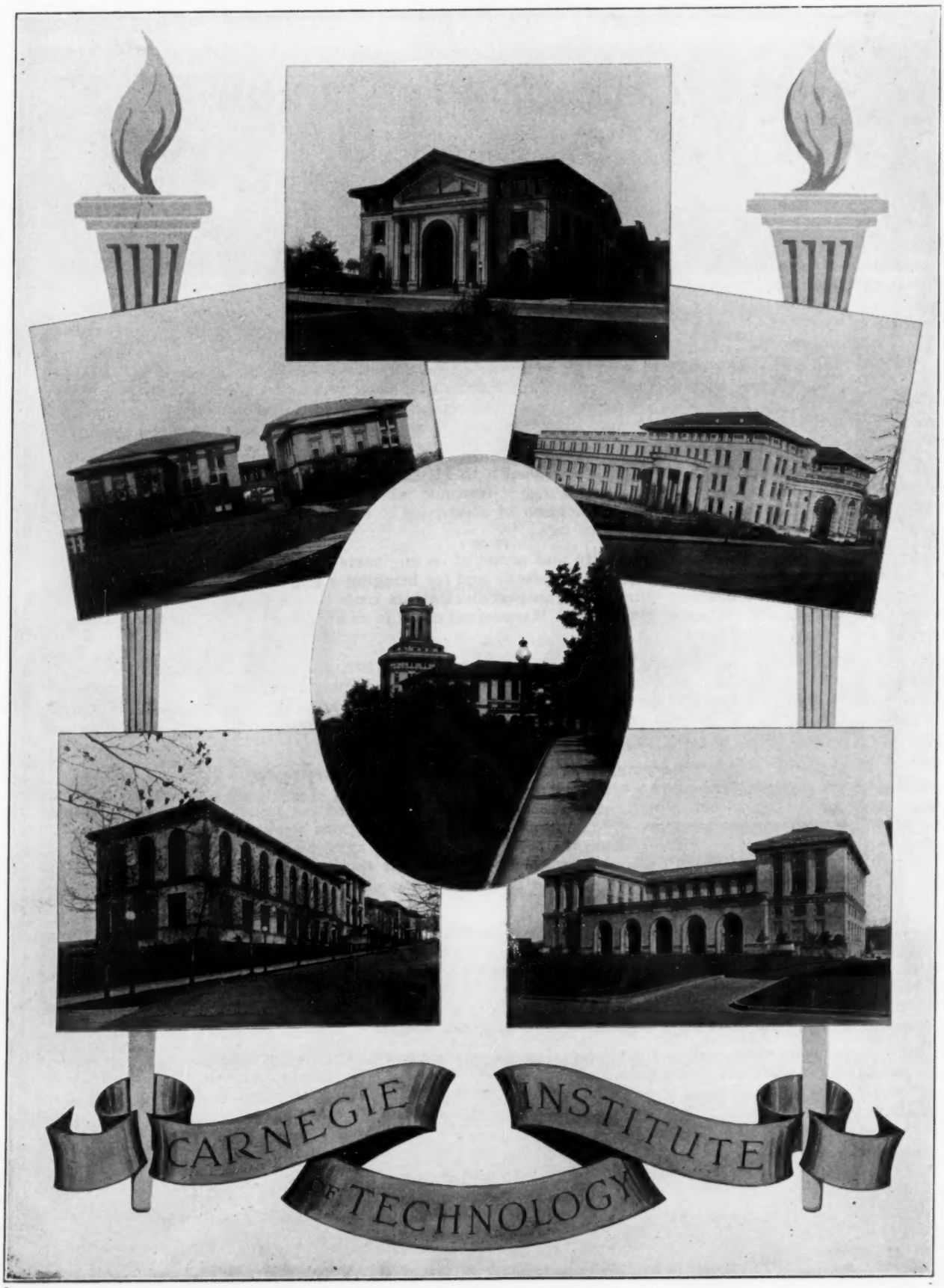
The people of Pittsburgh are in close touch with the thought and genius of men who have wrought so well in iron and steel and who are by electricity astonishing mankind by their marvelous achievements, and this Convention of your organization for the exchange of sentiments, of thoughts, of methods and of ideas on the important subjects in which your organization is interested is one of the promising things of our present day.

The efforts of your organization have been eminently successful and what you have done in the past as an organization is but a prophecy of what you will be able to do in the future. If we could but draw back the curtain of the future, we would not only be astonished but mystified by what is in store for us and for coming generations. We cannot foretell what inventions are in the brain of the future or what garments of glory will be woven on the loom of the coming ages, but we do know that honest endeavor of men who associate themselves together not only for the benefits which they may individually derive, but for the good which they may do for others, is not in vain, and in this kinship of heart and unity of purpose you are real benefactors.

The members of your organization are creators. Every mill, shop, factory and plant began with an idea. By thought that idea developed into a plan, and then through mind-directed effort it materialized into an actuality with physical form and physical characteristics. All the development about Pittsburgh is but the thought of engineers operating in harness of steam and iron and steel. The thinker and the creator must precede the worker. Thus the man who thinks and plans and dreams and creates paves the way for the material things that make us great.

In welcoming you to Pittsburgh, I wish you to remember that our best product is manhood and womanhood. We are justly proud of our material wealth and greatness, but we are not afraid to be judged by the prevailing type of our manhood and womanhood. May your visit here be pleasant and profitable, and when you separate and go your several ways may something gathered here last through life as a remembrance of Pittsburgh.

Cordially yours,
W. A. Magee
MAYOR.


CARNEGIE INSTITUTE OF TECHNOLOGY

Exhibitors and What They Will Exhibit

Booth No. 82

Alliance Machine Company
Alliance, Ohio

This company will have on display models for the patent interlocking ladle crane trolley, showing both designs of trolley with the motors interlocked and also the drums interlocked. Rope type stripper, stiff column soaking pit cranes, their patented forge manipulators for handling billets of all descriptions with either a press or hammer, whichever the visitor should be interested in; also models on new developments in car dumpers, etc.

The exhibit will be in charge of H. Y. Stuckey, Chief Engineer of the company, and C. A. P. Wise.

Booth No. 68

Allis-Chalmers Manufacturing Company
Milwaukee, Wis.

The Allis-Chalmers Company will have their booth fitted up as a reception room for its many friends in the iron and steel industry.

A pictorial display of the later equipment of particular interest to the men of the industry will be shown. This will cover the company's lines of power, electrical and industrial machinery, and especially steel mill electrification.

They will be represented by Messrs. R. W. Davis, William Wray, H. W. Bartling, J. K. Keogh, E. F. Kochman and others.

Booth No. 159

American Engineering Company
Philadelphia, Pa.

The "Lo-Hed" Mono-Rail Electric Hoists, which will be on exhibition in Booth 159 at the Exposition, have an exclusive feature that not only inreases their utility on any material handling job, but also greatly increases their field of application. They are designed so that they operate in the minimum headroom; considerably less capacity for capacity than any other hoist on the market. This is accomplished by having the hoisting drum on one side of the I-beam track and the motor on the other side—an arrangement which permits the load block to be drawn up inside the frame of the machine until it practically touches the under side of the rail. The construction of these hoists is exceptionally fine. Gears are of high carbon steel, drop forged. Roller bearings are used throughout. The mechanical efficiency is 80 per cent with a factor of safety of 5 at full load. Safety, accessibility and ruggedness are outstanding features.

"Lo-Hed" hoists are made in capacities of from 1,000 to 12,000 lbs. There are five types (1, bolt suspended; 2, plain trolley, floor operated; 3, hand geared trolley, floor operated; 4, motor driven trolley, floor operated; 5, motor driven trolley, cab operated), all of which are available for either a.c. or d.c. operation.

Booths Nos. 111 and 118

Appleton Electric Company
Chicago, Ill.

The Appleton Electric Company will have on display Unilets, outlet boxes and covers, switch boxes and conduit fittings, Reelites and Mogul Reelites, take-up reels for all sizes of power cable.

Representatives of the company who will be in attendance are Messrs. A. S. Merrill, E. G. K. Anderson, G. H. Conn and C. L. Snyder.

Booth No. 21

Automatic Reclosing Circuit Breaker Company
Columbus, Ohio

The items of chief interest in the exhibit of the Automatic Reclosing Circuit Breaker Company will be automatic reclosing circuit breakers which may be operated manually, and manually operated enclosed circuit breakers for the protection of individual motor circuits. These two items represent the developments in circuit breakers which the company has made in the past year.

The automatic reclosing circuit breaker arranged for manual operation provides practically all that can be asked for in a circuit breaker. Without a question, there has been some hesitancy in the past in applying automatic reclosing circuit breakers to important mill feeders because of some doubt as to what should be done in event that they failed to operate. While the failure to operate may be regarded as an unusual occurrence, the possibility of such failure always exists with automatic control, and in order to overcome this objection the company has developed a circuit breaker which may at any time be operated in the same manner as manually operated circuit breakers to which steel mill engineers are accustomed.

The enclosed manually operated breaker for individual motor protection is designated as a Safe-For-All circuit breaker because it is designed to meet the requirements of safety from a standpoint of not only the operating man, but the maintenance man as well. This circuit breaker embodies the latest and most advanced thought on the subject of safety switch and circuit breaker protection for individual motor circuits. It is, in fact, a combination of safety switch and overload circuit breaker designed to be "safe for all" who have occasion to operate it or work on it.

In addition to the above, the company will exhibit their type "TR" thermal relay which provides protection against excessive temperature rise on motors and other electrical equipment, and other miscellaneous relays in which steel mill engineers are likely to be interested.

Booths Nos. 93-94-95

Baker R & L Company
Cleveland, Ohio

The Baker R & L Company will exhibit a full line of heavy duty storage battery trucks and tractors, including the latest model in three movement cranes.

The exhibit will be under the supervision of the H. E. McCoy Company, 1023 Bessemer Bldg., Pittsburgh, who represent the Baker R & L Company in Western Pennsylvania and West Virginia. H. E. McCoy, George H. Criss and George I. Gilson will be pleased to meet their friends and will be assisted by M. A. Watterson, sales manager; D. L. Darnell, assistant sales manager, and Harry Greig, field engineer, from the factory.

The Baker R & L Company have the distinction of being the pioneers in storage battery vehicle manufacture. The original company being the Rauch & Lang Carriage Company, who developed the leading electric pleasure car and the Baker Motor Vehicle Company, who pioneered the commercial electrical vehicle.

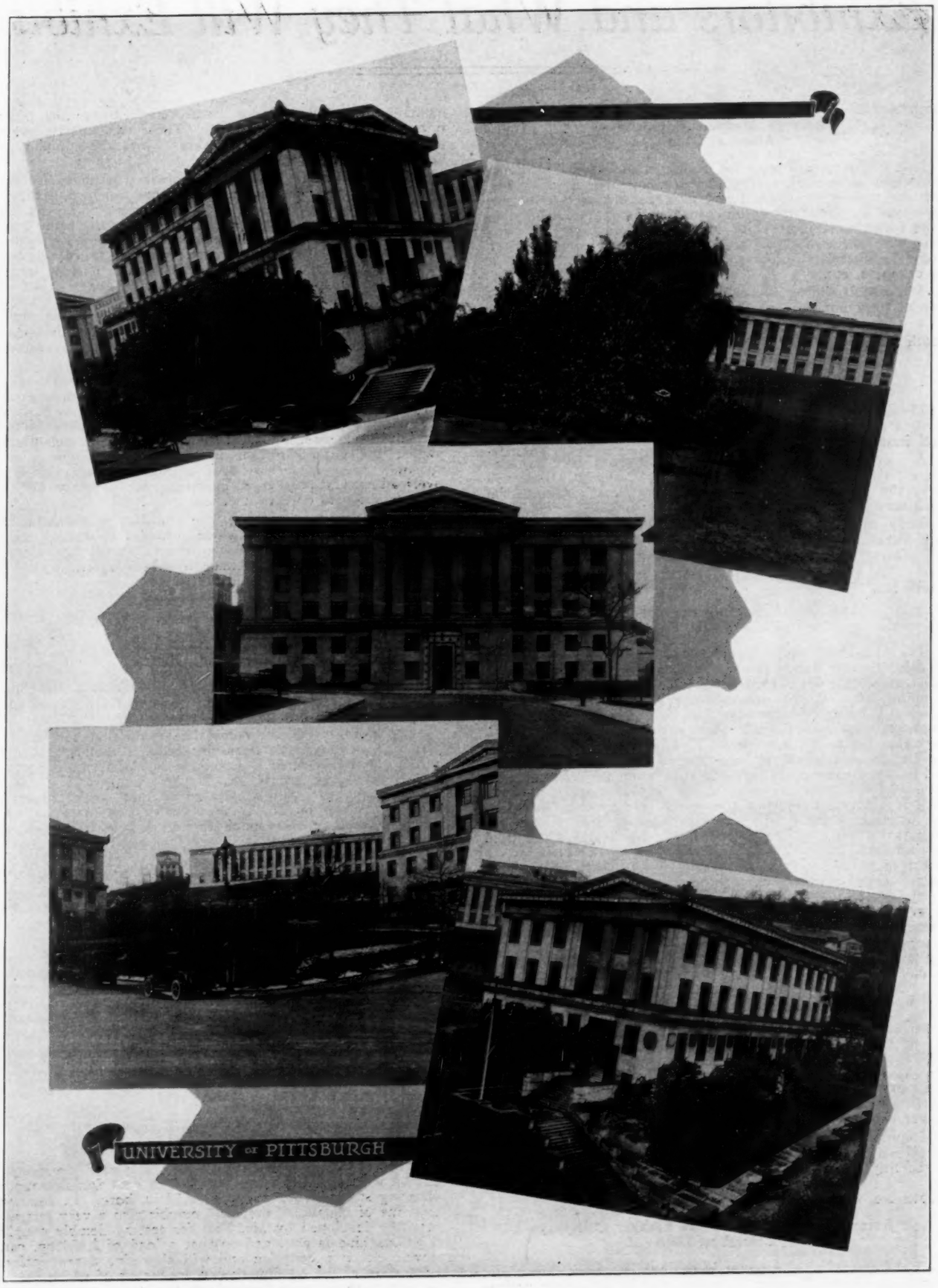
The combination of these two companies in 1915 resulted in the Baker R & L Company, who have forged ahead in the industrial line, and to their credit may be placed the development of the worm drive and the perfecting of the duplex compensating power unit suspension, as well as the standardization system of truck manufacture.

We welcome you to visit our exhibit. We will do our best to entertain you.

Booth Nos. 84-85

Bartlett Hayward Company
Baltimore, Md.

The equipment which the Bartlett Hayward Company will exhibit will consist of a complete line of Fast flexible couplings, showing sizes from 1 in. bore to 12 in. bore. In addition to this line of couplings, they will exhibit also a very interesting machine developed by Mr. Fast for testing flexible couplings. This machine is arranged so that a load of 2,500 hp. can be developed on a coupling and will also give a practical demonstration of the oil film theory, by means of which they will be able to thoroughly demonstrate the fact that the load carrying surfaces of the fast coupling do not have a metal to metal


UNIVERSITY OF PITTSBURGH

contact and that the load is positively carried on a film of oil, which of course eliminates all possibility of wear.

Those in attendance at our booth will be Messrs. G. Fast, M. T. Maguire and J. P. Flippen.

Booth No. 115

Bussmann Manufacturing Company
St. Louis, Mo.

A latest edition of the well known booklet, "Fuseology," will be distributed at the Bussmann Manufacturing Company's booth. This little book gives in clear, concise language the reason for fuseing, what a fuse is, what to do and what not to do when a fuse blows. It is chucked just full of valuable information for the technical man as well as the layman. Everyone would do well to obtain a copy before leaving the convention.

Another interesting part of the Bussmann display is the carton used on their plug fuse. The carton idea was originated by the Bussmann Company for the purpose of giving the dealer a unit sale of profitable proportions and to give the user an emergency supply of fuses. Everyone connected with the electrical industry knows that there is a great lack of knowledge on the part of the general public regarding the proper use of electricity. Printed on the Buss carton is information that every fuse user needs. It tells why fuses blow and what to do when they blow. It impresses on the user the necessity of proper fuseing and tends to raise in his esteem the whole electrical industry. Being on the carton, this information is in the hands of the user when he needs and wants it most—when a fuse blows.

Booth No. 22

Chicago Fuse Manufacturing Company
Chicago, Ill.

This exhibit will include a complete display of the various products of the company, including particularly their Union renewable fuse, which is especially constructed for use in circuits subject to frequent fluctuations in the current, such as are often found in steel mills, and for that reason will be of special interest to electrical engineers and electricians attending the convention.

Mr. Charles C. Lafferty will be in charge of the exhibit, and assisting him will be Messrs. A. E. Tregenza, E. J. Hamilton and J. M. Boak.

Booths Nos. 15-16

Chicago Pneumatic Tool Company
New York, N. Y.

The exhibit of this company will cover their entire line of portable electric tools, including track drills for rail bonding, pneumatic riveting and chipping hammers, pneumatic grinders, portable electric grinders for street railway and interurban service, pneumatic sand rammers and air drills for taping blast furnaces.

Mr. Edward Aplin will be in charge of the exhibit, assisted by Mr. R. F. Eissler, district manager, Pittsburgh Branch, and Mr. J. L. Westenhaver, district manager, Cleveland Branch.

Booth No. 59

Crocker-Wheeler Company
Ampere, N. J.

The exhibit of this company will consist of the following: Direct Current—1 size DW 30-hp. mill motor direct current equipped with roller bearings; 1 size 81 H, 80-hp., 230-volt, C.C.M., 600 rpm. motor; 1 size GL, 2-hp., 230-volt, 1,200-rpm. (C.M. or C.C.M. with condulets) motor. Alternating Current —1 size 10-R 25-cycle motor; 1 size 14-Q, or 15-Q or 16-Q frame squirrel cage induction motor. Also sample spare parts like: one-fourth set of size DW field coils; one-tenth set armature coils, size DW; 1 10-R stator coil; 1 stator coil for either 14-Q, 15-Q or 16-Q motor; 1 81-H armature coil; 1 81-H bearing and oil ring.

Those who will be in attendance are: Messrs. A. C. Bunker, B. C. Christian, H. B. Hussey, J. R. Lewis, J. Roe, S. Russell, Jr.

Booth No. 155

Delta Star Electric Company
Chicago, Ill.

This exhibit should be of real interest to the electrical engineers and steel mills. We will show gang operated disconnecting switches, bus bar supports of various sizes, air break switches and a complete line of high tension switching equipment such as used where voltages are 2300 volts and above. There are quite a number of new developments in this field and it is hoped to display a good part of this equipment.

Booth No. 53

M. H. Detrick Company
Chicago, Ill.

This company will exhibit a model showing a Detrick arch. This arch will be the type used generally in connection with traveling grate stokers for the burning of anthracite and bituminous coals and coke breeze. The main features of the arch are: 1, Simplicity of construction; 2, Minimum number of shapes required, there being only two different shapes required for the complete arch; 3, Center suspended tile; 4, The construction of the fan ignition and fan end arch. The construction of the main arch is the same that is used in connection with every type of boiler and stoker, and also in connection with heating furnaces and annealing ovens. There will be on exhibit blueprints of interesting types of heating furnaces.

Mr. Louis Ellman will be in charge of the display.

Booth No. 150

Dravo Doyle Company
Pittsburgh, Pa.

This company will exhibit in operation the latest and most timely products of the American Engineering Company, the DeLaval Separator Company and the DeLaval Steam Turbine Company:

Lo-Hed Monorail Hoists, plain and motor driven trolley. These hoists will be so shown as to bring out their unusual mechanical perfection and accessibility as well as the low head room feature.

DeLaval Portable and Stationary Transformer and Lubricating Oil Purifiers. The portable unit will be shown in operation on transformer oil.

DeLaval Worm Gear Speed Reducers. The latest type worm gears especially designed and produced for industrial applications and including features of especial appeal to the practical operating man.

DeLaval Flexible Couplings. An old established quality product, now rapidly increasing in popularity because it requires no lubrication, is not affected by dust and is reasonable in cost.

This equipment has been selected for exhibition as representing in each case the latest developments of particular interest to the industrial electrical engineer. It has already been widely adopted by the steel industry.

Mr. William Buhl will have charge of the exhibit, assisted by Messrs. W. L. Vansant, David Henderson, H. M. Graham, W. P. Berg and H. P. Mann.

Booths Nos. 80-81

The Electric Controller & Manufacturing Company
Cleveland, Ohio

The display of this company will consist of full magnetic controller with current limit acceleration and overload protection for blooming mill screwdown motor; full magnetic form "H" dynamic braking controller for hoist motion of electric traveling crane; Youngstown safety stop; Type Q brake; traveling nut type limit switch; a.c. and d.c. magnetic contactors; E. C. & M. automatic compensator; manual automatic compensator; Type NC 40-deg. squirrel cage induction motor.

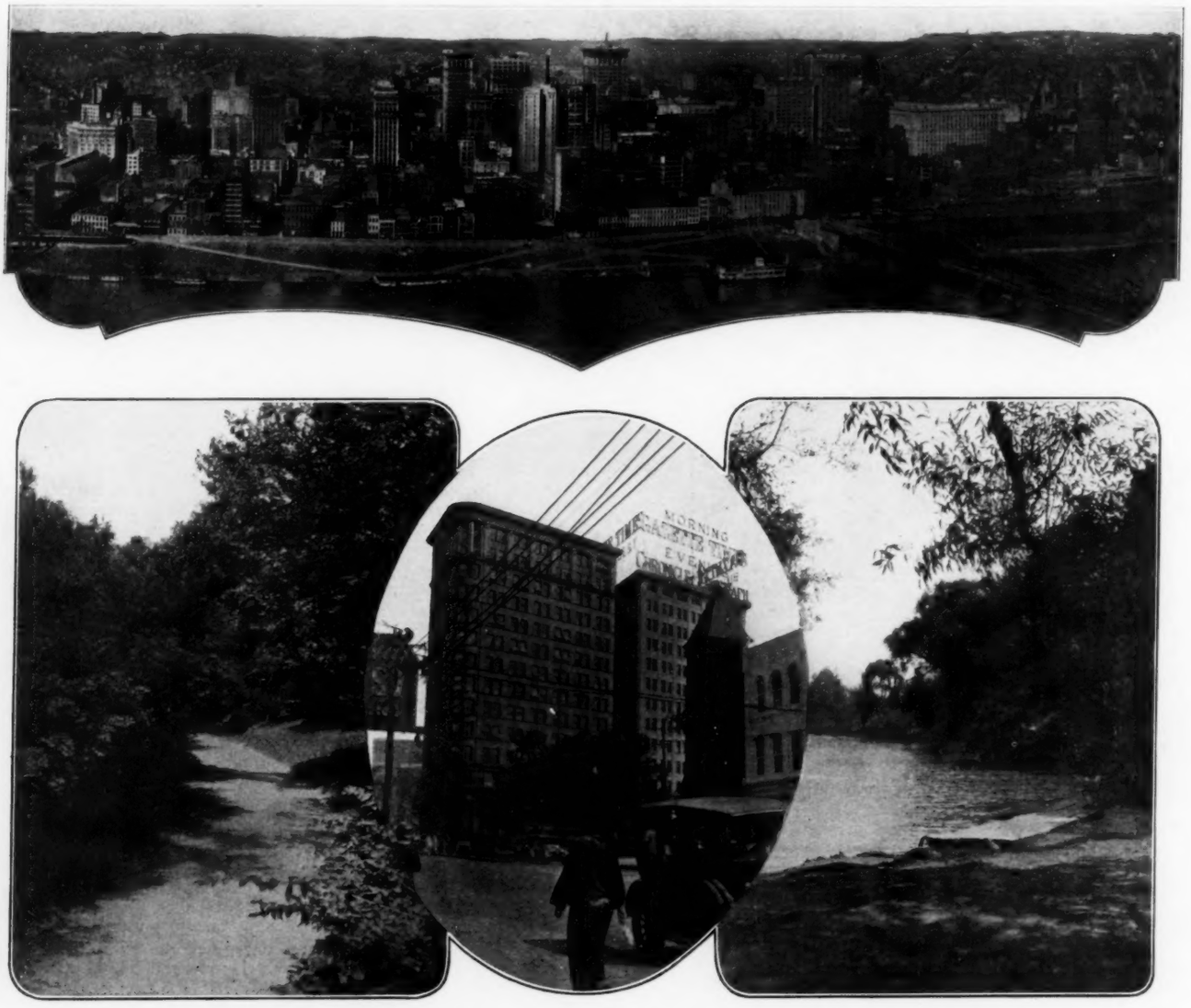
The men in attendance will be A. C. Dyer, J. C. Snyder, R. T. Johnson, A. J. Freund, W. D. Falkenstein, E. C. Ryan, H. S. Richardson, F. R. Fishback and R. G. Widdows.

Booth Nos. 96-97

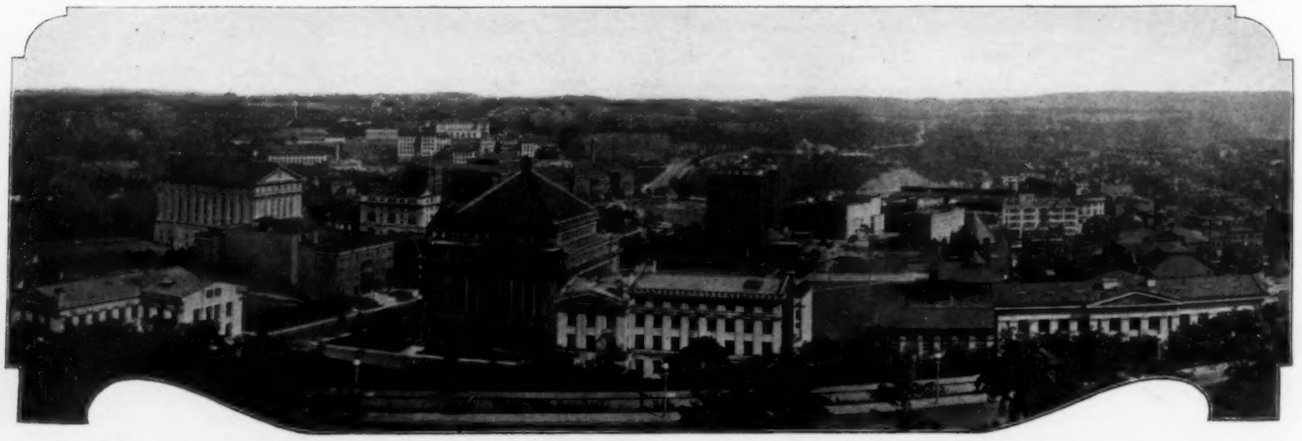
Farrell Foundry & Machine Co., Inc.
Buffalo, N. Y.

The main item of their display at the Exposition will be a complete Sykes gear generator, size No. 1½, set up and operated by a skilled mechanic from their plant. They will cut gears of all sizes and pitches within the range of the machine. They welcome the closest inspection and will give unlimited time to interested parties. They will also have a

Pittsburgh Prepares for Iron and Steel Exposition



Pittsburgh's parks abound in natural scenery. Insert—A section of East Liberty's shopping district.



Pittsburgh's "Civic Center", considered one of the most remarkable in the country, where are grouped the buildings of a dozen institutions, schools and organizations.

photograph stand with a large collection of pictures illustrating all sizes and types of Sykes gears and of totally enclosed self-contained reduction units. A number of blueprints will be on hand to show the details of design of their reduction cases and of the gears themselves. They will have on exhibition in addition to the gears produced on the gear cutting machine gears which have been made for special purposes and which will prove interest to visitors.

In addition to the shop man operating the gear cutting machine, their Mr. Brandt and Mr. Kuhns will be in attendance. Mr. Sykes, inventor of the gear cutting machine, will also be in attendance for a day or two, filling appointments.

Booths Nos. 120 to 129

General Electric Company
Schenectady, N. Y.

The apparatus which the General Electric Company expects to exhibit will include the following: 1 Mill type (Type MD) motor complete with control; 1 polyphase and adjustable speed brush shifting 3-phase motor with operating switch; 1 small Sprague hoist; 1 steam flow meter; 1 small industrial type squirrel cage induction motor, and various kinds of control apparatus. Other apparatus will also be included in the exhibit.

Booths Nos. 110-119

Ludwig Hommel & Company
Pittsburgh, Pa.

They will have on display apparatus manufactured by the Sangamo Electric Company of Springfield, Ill., the Wagner Electric Corporation of St. Louis, Mo., the States Company, of Hartford, Conn., and the Economy Electric Devices Company of Chicago, Ill.

A very interesting exhibit of the new Fynn-Weichsel motor shows the effect of the "motors that corrects power factor." A standard induction motor-generator set and a motor-generator set using the Fynn-Weichsel motor are arranged so that they may be operated separately or in parallel, and so that the load on either set may be varied. Instruments are mounted so that the effect of the different operating condition on the power factor of the supply circuit may be observed.

The new Sangamo horizontal two element polyphase watthour meter is displayed. One of these meters is so connected that it measures the total kwh. used by the Wagner exhibit. One of the outstanding features of the new meter is that by observing the speeds of the two separate discs the power factor of the circuit being measured may be easily and quickly determined. This meter further affords a quick and accurate check on the correctness of the meter connections, and as to whether from any cause one potential element or circuit may be open, a common cause of error in polyphase metering.

The States Company are manufacturers of meter testing apparatus, and a few of the standard loading and testing devices are shown.

Aluminum field coils for street railway motors, crane motors, d.c. mill motors, etc., are rapidly proving their superiority to copper coils in their ability to stand up under severe service. A section of this new type of coil is shown and will prove most interesting.

The exhibit will be in charge of Charles A. Swartz and H. S. Michael.

Booth No. 69

Hyatt Roller Bearing Company
Harrison, N. J.

The Hyatt Roller Bearing Company will exhibit a complete line of Hyatt bearings for steel mill equipment and for mill motors, with models illustrating the simplicity of applying Hyatt bearings to motors. Hyatt bearings mounted in glass, driven by small motors, will visually demonstrate the positive oiling action.

The following engineers of the company will be in attendance: Messrs. H. A. Brown, Jr., P. C. Gunion, Earl E. Eby, W. B. Wachtler, J. M. Kelly and C. C. Thompson.

Booth No. 47

Iron City Electric Company
Pittsburgh, Pa.

They will have on display Wheeler reflectors, for industrial lighting; Rome super service cords and cables, for mill and mine use, as well as a few other electrical specialties.

Mr. R. J. Kuzel, of the Wheeler Reflector Company, and Mr. Walter O'Brien or Mr. R. C. Gray, of the Rome Wire Company, as well as their Mr. J. C. Haines, will be attending the Exposition and will be very glad to go over the different lines that will be on display.

Booth No. 145

J. A. Jaques
Pittsburgh, Pa.

The products of the following companies will be exhibited:

Edwin L. Wiegand Company, Pittsburgh, Pa. They are manufacturers of Chromolax electrical heating units and will show a full line of these units especially adapted for steel mill application. These strip heaters will be shown in various wattage capacities and at least three metal coverings. E. N. Calhoun, sales manager, will be in attendance

Signal Engineering & Manufacturing Company, New York, N. Y. They will show various signal and code calling systems, including the new series fire alarm system. They will also show their very latest line of power gongs and relays which is an entirely new departure from the old style clapper gong. A. W. Hall, engineer and sales manager, will be in attendance.

Taplet Manufacturing Company, Philadelphia, Pa. They will show a line of conduit fittings and will call special attention to their line of vapor proof fittings. They will be prepared to distribute their latest catalogue. A factory representative will be in attendance during the show.

Booth Nos. 57 and 58

Keystone Lubricating Company
Philadelphia, Pa.

In conjunction with their complete line of lubricants, they will show a few photographs of installations of the Keystone safety lubricator. This system is being generally adopted by the steel industry, not only for cranes and ore bridges, but also for boring mills, mill tables, levelers, upsetting machines and other units, and it is recognized as the most improved safety feature in present day lubrication methods.

There will be on display the Keystone converter cup, through the use of which this safety lubricating system is made automatic and kept under constant pressure. Data will be available covering some remarkable savings in cost of lubricants, bearings and general maintenance.

They will show samples of greases for open gears, for use in the Venango gravity cup system—also liquid greases for ring oil motor bearings, and densities for ball and roller bearings. There will be demonstrated on a hot plate the relative loss of viscosity of motor oil and liquid grease, showing the ability of the liquid grease to retain its density and non-creeping qualities under operating temperatures.

Those to be in attendance are Messrs. H. A. Buzby, K. K. Buzby, George W. Hall, C. O. Norstrum, F. D. Street, T. B. Little and O. V. Schauer.

Booth No. 25

C. H. McCullough Engineering Company
Pittsburgh, Pa.

This company represents the Ackurate Rubber Company of New York, who are manufacturers of high class tape which is put out under the names of "Ackerman Friction Tape" and "Candee Rubber Splicing Tape." Mr. Candee, president of this company, will be on hand to give any information in regard to this product.

They will also have a display of "EMB" unbreakable jointless and rustless grid type resistance which is especially adapted to steel mill and heavy duty service, and will also have a display of welded steel case controller especially designed for steel mill work and will be shown for the first time in this country at this convention. They will also show in this country for the first time a "dinkey" controller equipped with "EMB" unbreakable jointless and rustless grid type resistance.

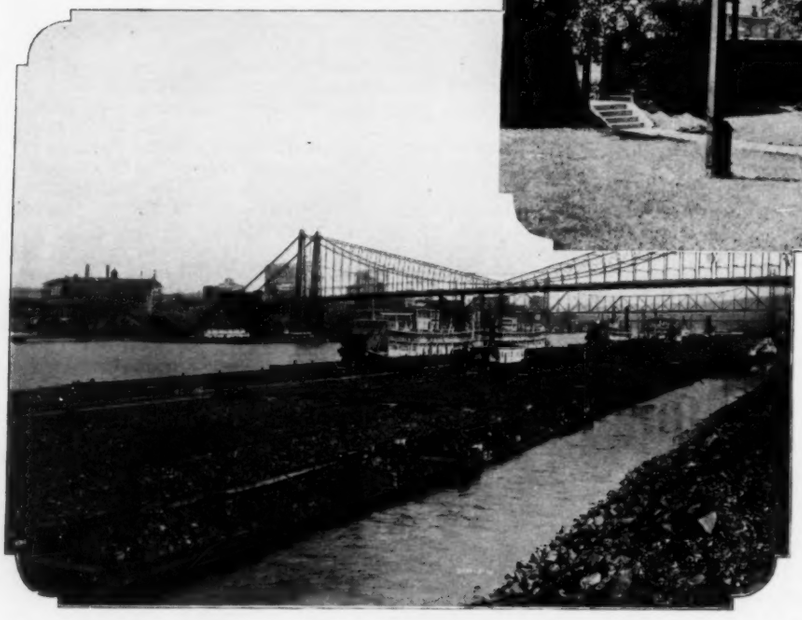
They will also display gears and pinions made by the Van Dorn & Dutton Company, Cleveland, Ohio, gear craftsmen for years.

Booth No. 11

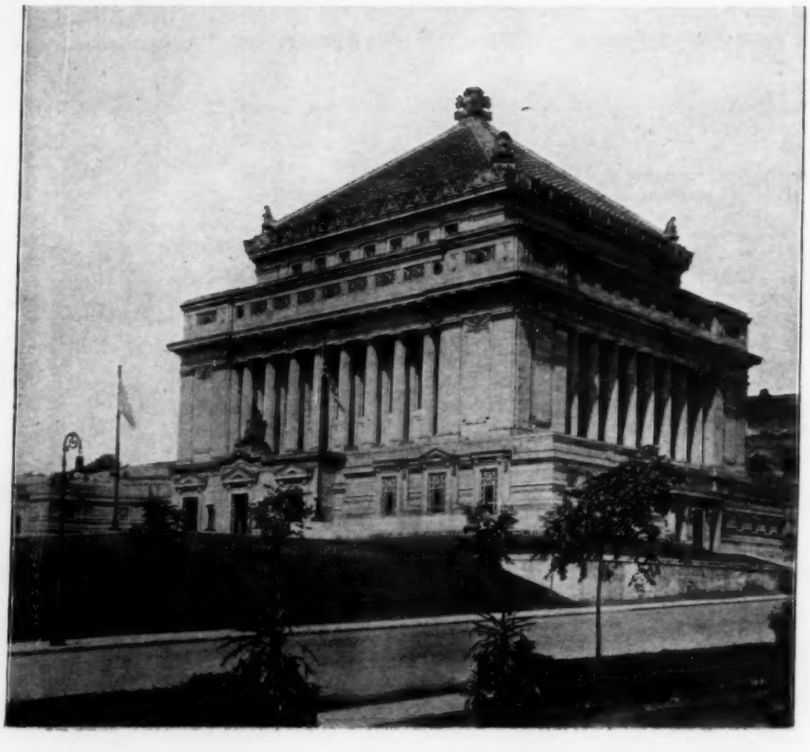
McGraw-Hill Company
New York, N. Y.

The McGraw-Hill Company will have available at its booth this year current issues of Electrical World, Industrial Engi-

The old Block House built at the confluence of the Allegheny and Monongahela Rivers to protect the early settlers from the ravages of the Indians.



A typical scene at the Point today. Pittsburgh's river tonnage exceeds that of the world's four largest ports combined, averaging over 24,000,000 tons annually.



Soldiers and Sailors Memorial Hall

neer and Power, publications that are devoted to the different phases of engineering and operating problems of steel mill engineers. There will also be on display the results of an exhaustive investigation of the buying habits of industry. This will consist of a number of large charts and diagrams giving details of industrial organizations and how equipment is specified and purchased.

The following members of the editorial and business organization will be in attendance: Edgar Kobak, D. H. Braymer, A. J. Whitcomb, L. W. W. Morrow and F. A. Annett.

Booth No. 154

Moloney Electric Company
St. Louis, Mo.

They will show here a small transformer removed from the case, showing the general construction of the working parts of the transformer. They will also show their new ratio adjuster and have a complete set of literature on Moloney transformers to be given out to all who are interested.

They invite all who wish to do so to use their space for headquarters and sitting rooms whenever a rest is needed from the strenuous work of the meeting.

Booth No. 89

National Carbon Company, Inc.
Cleveland, Ohio

The National Carbon Company will show in their exhibit raw materials from which their brushes are made as well as showing brushes in various stages of manufacture. There will also be a quantity of used brushes, showing average results ordinarily obtained with their product. They will also display welding carbon materials, including plastic carbon paste, carbon and graphite contacts, and various forms of carbon specialties will form another part of the exhibit. In addition to the foregoing, they expect to have mechanical devices for showing certain effects on brushes caused by mechanical arrangements, which will be of interest to those who witness the exhibit.

The following members of their organization will attend: Messrs. R. H. Johnson, R. J. Feuchter, N. F. Bowman, V. J. Nolan, J. L. Green and E. A. Williford.

Booth No. 158

The Norma Company of America
Long Island City, N. Y.

This company will have on display samples of ball and roller bearings of various types, together with several moving exhibits to illustrate the construction and operation of these bearings. One portion of the exhibit will consist of Norma precision open and closed types of annular ball bearings as well as ball thrust bearings, while another section will consist of Hoffman roller bearings of both standard and self-aligning types and Hoffmann ball thrust bearings.

Particular emphasis will be laid on the Hoffmann precision roller bearing for use on electric motors in the steel mill, and illustrations will be shown covering the methods of mounting these bearings to various types of mill motors.

Hoffmann rollers and roller gauges will also be on exhibition and a limited quantity of them will be distributed to those in attendance. These rollers are held to an accuracy of one-tenth of a thousandth of an inch in diameter and are very useful in checking micrometers, gauges, etc.

They will also show the Norma minimeter, a precision measuring instrument of the highest quality. This will be used to demonstrate the extremely close tolerances used in the making of precision ball and roller bearings.

The exhibit will be in charge of Mr. D. E. Batesole, together with Messrs. R. E. Hecker and G. C. Stone.

Booth No. 18

The Ohio Electric & Controller Company
Cleveland, Ohio

They will have on display appropriate pictures, magnet parts and magnet controller in operation.

F. W. Jessop, R. O. Wertz, H. A. Saunders and P. H. Diver will be there primarily to renew acquaintance with a number of their old friends whom they do not see frequently.

Booths Nos. 29-30-31

Otis Elevator Company
New York City

The equipment to be exhibited covers devices used for the automatic operation of blast furnace skip hoists; the full magnetic controller shown in operation in conjunction with the automatic stop motion switch, the master switch, and the latest form of magnet shoe brake for hoist service. The operation of the electrical parts may be fully observed, both individually and in relation to each other, thus giving the clearest possible view of the entire system employed on the blast furnace hoists built by the company. In the mechanical design no pains have been spared to produce the most reliable equipment in every detail, and the accessibility of all parts for rapid interchange has been clearly established by the reports of service from all quarters of the world.

Booths Nos. 60-61

The Packard Electric Company
Warren, Ohio

They are going to have on display distribution and power transformers. Because of the great amount of space required for large power transformers, they are going to demonstrate their ability along this line by means of component parts and sections of component parts. One thing which will be of particular interest, which will be on display, will be a Packard tap changer, which is a patented device externally operated for changing the ratio on the high voltage side of power transformers.

The following representatives of the Packard Electric Company will attend: H. M. Leathers, W. F. Parker, R. W. Beard, J. H. Burroughs, O. T. Hall and Jos. C. Bowman.

Booth No. 76

Payne Dean Limited
Stamford, Conn.

Payne Dean Limited will exhibit an electrically operated high pressure 600-lb. cast steel valve fitted with Dean control system for local and remote control of the valve. Controlling apparatus for operating the valve will also be exhibited. The Dean remote boiler level water gauge will be shown, which is the first successful gauge of its kind indicating at a remote point the level of water in the steam boiler. A Dean load indicating system, showing automatically the total load in power plants, will also be exhibited.

Photographs, prints, and other material showing the application of Dean control to all types and classes of valves used in the steel industry, will be available, and Mr. Payne Dean and Mr. H. S. Stockdale will be in attendance continually.

Booth No. 98

Railway & Industrial Engineering Company
Greensburg, Pa.

They plan to have in their exhibit switching and protective equipment. The interchangeable insulator unit idea will be featured, showing the unit with forged steel pin and pressed metal cap. The forged steel rotors used with the various gang and air break switches will be shown. Disconnecting switches of different ampere capacities with the full floating, self aligning contacts will be shown. Miscellaneous bus bar clamps and brass and copper connectors will be on exhibition.

Booths Nos. 140-141-148-149

Reliance Electric & Engineering Company
Cleveland, Ohio

Their exhibit will consist of the Type T line of heavy duty d.c. motors especially designed for steel mill general service and which has been greatly extended in the past year. The new Type "AA" line of squirrel cage motors will be on exhibit, showing the larger sizes of skeleton frame construction, which have been added since the last convention. The Type "AS" adjustable speed motor of armature shifting design for special wide speed range application will also be exhibited.

Men in attendance: Messrs. C. L. Collens, H. Morly Hitchcock, A. M. MacCutcheon, Harry J. Fisher, B. J. Ballard, A. B. Coffman, R. O. Herbig, E. E. Helm, Irwin Stegmeier, R. A. McDowell.

Booth No. 17

Rollway Bearing Company, Inc.
Syracuse, N. Y.

They propose having on display actual installations of "Rollway" bearings in the Westinghouse SK and 47-J, Pawling & Harnischfeger Type M, General Electric MD, Crocker-Wheeler W, and Westinghouse MC types mill motors; also examples of crane hook mountings using the "Rollway" crane hook thrust bearing and in addition a number of actual installations of their wide series bearing, typifying their use on roll table rolls, ingot cars, larry cars, etc. They will also exhibit a complete line of the various types of bearings they manufacture.

The exhibit will be in charge of Mr. Samuel Farrell, together with Messrs. Fred Clapp, J. H. Evans and J. T. R. Bell.

Booth No. 144

SKF Industries, Inc.
New York, N. Y.

In the exhibit of this company a range of Skayef self-aligning and Hess-Bright deep groove ball bearings and Atlas balls will be shown along with interesting models which will bring out the anti-friction qualities of ball bearings. A large ball and roller bearing, such as used in steel mill applications, will be shown and suitable blueprints of steel mill mountings will be exhibited to interested parties.

The following men plan to be in attendance: Messrs. R. H. DeMott, T. H. Dessez, E. B. Haines and F. E. Ericson.

Booth No. 20

Square D Company
Detroit, Mich.

The exhibit which this company will have at the Exposition will be of great interest to iron and steel engineers. The Square D 80000 Series, the switch which has excited such favorable comment by industrials ever since its development, will be featured in the display. Demonstrations of the two much talked of features—the individual base construction, by which switch parts can be removed from the front of the switch in a few minutes' time, and the cover control with the key—will be made. The 76000 line of straight connected, quick make and break, single throw motor starting switches will also be on display. Literature descriptive of the complete Square D line will be available.

Messrs. E. L. Pittinger and T. R. Gano will have charge of the exhibit.

Booth No. 73

Standard Underground Cable Company
Pittsburgh, Pa.

This company will exhibit samples of various types of bare and insulated electric wires and cables for aerial and underground service, also samples of outdoor and indoor cable terminals and cable junction boxes. A feature of the exhibit will be a demonstration of joint making on lead covered underground cables.

The company will be represented by Messrs. A. A. Anderson, A. F. Hovey, E. S. Simkins and Max Rubenstein.

Booth No. 88

Thompson Electric Company
Cleveland, Ohio

This company will exhibit the Thompson safety lowering switch, or disconnecting hanger, together with accessories such as auxiliary pulleys, fittings and chain; various improvements and new adaptations will be shown.

The exhibit will be in charge of Mr. A. J. Thompson.

Booth No. 26

United States Graphite Company
Saginaw, Mich.

A complete display of the various grades and types of "USG" motor and general brushes and other carbon products will feature their exhibit. Lubricating graphite, graphite greases and other "Mexican" graphite products of especial interest to the steel industry will also be shown.

Representatives attending will be: Messrs. F. B. Godard, C. W. Adams, R. J. Edmiston and C. R. Springer.

Booths Nos. 130-139

V. V. Fittings Company
Philadelphia, Pa.

The V. V. Fittings Company, with factories and main offices located in Philadelphia, will, as usual, present a large and varied exposition of their comprehensive line of reversible and interchangeable V. V. fittings as well as a complete display of their line of V. V. safety switches. Many new, attractive and interesting models of their latest types of safety switches and devices will be exhibited for the first time. These devices are of exceptional interest to those appreciating high grade, safe, safety devices of unusual merit for their mechanical and practical construction and operation.

Mr. Phillip H. Schaum will be in charge of this exhibit, with a competent staff assisting.

Booths Nos. 50 and 51

Electric Service Supplies Company
Philadelphia, Pa.

This company will exhibit electric contact or third rail apparatus as used in electric haulage, conveyors, cranes, etc., consisting of various types of insulators for supporting the third rail and particularly the under running contact type which conveniently adapts itself to the use of two or more conductors for multi-phase operation or remote control, including line of various types of special third rail shoes, trolleys, collectors, etc.

Complete line of Keystone and Garton-Daniels Lightning Arresters adapted to service up to 20,000 volts. Complete line of trolley wire suspension material, including insulated hangers, ears, frogs, etc. Complete line of tools for electric repair shop equipment, including well known and improved type of Segur coil winder and spreader and in addition taping machines, bar bender and similar apparatus. Also, the Peerless line of shop tools, including the Universal heavy duty armature machine, Peerless Hydraulic pinion puller, etc. Aetna commutator smoothing stones.

This company specializes particularly on materials of the character above mentioned rather than on standard line of electric lighting supplies.

Booth No. 158

J. Frank Lanning & Company
Pittsburgh, Pa.

They will have two electric hoists, one 1000 lb. and one 1 ton capacity. They will also have a small roll of Krome Tan belt, a set of Stewart Brons bushings, and a few pigs of Motor Marine and Zero metals, Babbitrite compound and two babbitt ladles. A bearing will be exhibited that ran for days under a pressure of 3,000 lbs. per square inch, 32,000,000 ft. lbs. per minute, and it is in perfect condition. This bearing was used on a 4½ in. shaft.

Booths Nos. 32 and 33

Fuller-Lehigh Company
Fullerton, Pa.

The display exhibited by this company will center around pulverized coal as the general subject. There will be a working model of the Fuller-Kinyon conveying system for pulverized coal which will show the general features embodied in this device; also, a working model of an electro-pneumatic switching valve which is used in the conveying system and which permits remote control of the fuel feed to all individual furnace bins by push button operation so that irrespective of the length or size of line and the number of furnaces or their respective locations, absolute control of the whole system is effected by the operator from a central switchboard conveniently located. There will be small size models of the vertical and horizontal flare type burners, a small model of a vertical waste heat dryer and a small model of the Fuller-Lehigh pulverizer.

Among those expected to be in attendance are, Mr. W. H. Fitch, H. G. Barnhurst, A. E. Douglass, L. W. Marso and H. A. Reichenbach.

Booth No. 44

Homestead Valve Manufacturinog Company
Homestead, Pa.

This firm will exhibit the Homestead Quarter Turn Valve and the Protected Seat Hydraulic Operating Valve, also the Protected Seat Globe Valve.

Homestead quarter turn valves are of the plug cock type, but have improvements which render them superior to other types of plug cocks on the market today. They are entirely sealed from leakage—bottom and top; the plug being placed in the body and sealed with a substantial packing gland. The plug is forced tightly to the seat in the closed position, and is held on the seat at all times by the improved locking cam. The Homestead valves of particular interest in the steel industry are the hydraulic valves for 500 lb. and 1,500 lb. pressure; the small size three and four-way valves for operating machinery by low pressure water, air, or steam; the large three-way valves, 4 and 6 in. for gas lines in open hearth and furnace departments; the Homestead-Hovalco combination blowoff valve, extensively used in boiler rooms; the protected seat globe valve for general steel plant service; and the protected seat hydraulic operating valve.

The company will be represented at the convention by Messrs. B. F. Schuchman, H. P. Ackerman, C. E. Powell, and other representatives.

Booths Nos. 48 and 49

Western Electric Company, Inc.
New York, N. Y.

This company will show some samples and display boards of the leading electrical supply apparatus and devices that they handle in a jobbing way. For instance, D and W fuses, Deltabeston wire, Victor friction and rubber tape, etc. In their exhibit room copies of their general catalog together with catalogs, booklets and pamphlets on devices that they think will be of interest to the steel engineers who will be in attendance.

Booth No. 72

Doubleday-Hill Electric Company
Pittsburgh, Pa.

This company will exhibit buss renewable fuses, steel conduit fittings, mannufactured by the Appleton Electric Company of Chicago, Ill., and distributors maintaining a large stock of Square D switches, Benjamin reflectors, Triumph motors, rigid steel conduit, Robbins & Myers fans, National X-ray reflectors, and American Steel & Wire Company rubber covered wires and cables.

Special display of the new Ilg portable ventilating fans to be given prominence at the exposition will be in charge of Mr. H. E. Slack and Mr. A. J. Steger, assistant.

Booth No. 19.

Mutual Electric & Machine Company
Detroit, Michigan

The exhibit of the Mutual Electric & Machine Company will consist of a display board showing a complete line of "Bull Dog" safety switches, quick-make and quick-break, for severe service duty. An illuminated photographic display of "Bull Dog" safety type, dead front switchboards for industrial plants will be a feature.

Those representing the company will be, Mr. C. W. Roy of Pittsburgh, Mr. S. B. Frank of Cleveland and Mr. C. E. Todl of Cleveland.

Booth No. 54

Republic Flow Meters Company
Chicago, Illinois

The Republic Flow Meters Company will exhibit their full line of instruments for efficiency work on the power plants and steel mills. These instruments consist of recording, indicating and integrating, steam, air, gas and water flow meters, as well as CO_2 recorders, and instruments for indicating and recording drafts and pressures. It is also their intention to exhibit the Republic Pyrometer, which is one of their latest developments, and will be shown for the first time at this exhibit. They will also have bulletins on power plant cost accounting for the benefit of the engineers that are interested in laying out a complete cost accounting system for their power plant.

Booths Nos. 70 and 71

Pittsburgh Electric Furnace Corporation
Pittsburgh, Pennsylvania

This company's exhibit will consist primarily of photographs of furnace installations, together with representative iron and steel castings made in the Electromelt furnace.

The representatives present at the convention will be W. B. Wallis, president; W. E. Moore, Mr. R. S. Kerns and H. E. Bromer.

Booth No. 79

Benjamin Electric Manufacturing Company
Chicago, Illinois

This company will show their removable reflector units known as the Type RR. The hoods are made in both cast iron and porcelain enameled steel, threaded to receive the neck of the porcelain enameled steel reflector made in various types such as the shallow bowl, dome, deep bowl, etc. These reflectors can, any of them, easily be removed for cleaning. The exhibit will also include some of the novel features of Benjamin lighting devices such as the Benox line of interchangeable equipment, connecting devices, water-tight and dust proof material, the latter including a glass covered unit which is particularly designed for steel mill lighting.

There will also be exhibited a line of Benjamin heavy duty wiring devices. A competent man will be in charge of the booth, who will be able to answer specific questions with reference to proper illumination. An interesting little souvenir of the convention will be presented to the engineers who call.

Booth No. 47

The Calorizing Company
Pittsburgh, Pa.

The Calorizing Company, 323 Oliver Building Pittsburgh, Pa., manufacturers of heat enduring and heat saving equipment, will show various heat resisting parts as follows: Calorized steel annealing box, calorized steel lead pots burned where not calorized; a short section of heavy calite skids used to replace water cooled pipes in continuous furnaces will be exhibited. The calorized metallic recuperator will be shown operating with a furnace under heat, plainly showing the preheat given the combustion air from the waste flue gases.

The representatives of the company will be, Messrs. B. J. Sayles, district manager; Harry D. Miller, sales engineer; A. R. Knight and Roger Stuart Brown.

Booth No. 132

Reed Air Filter Company
Louisville, Kentucky

The exhibit of the Reed Air Filter Company will consist of a complete bank of filters consisting of 16 units. There will also be a small miniature ventilating system with gages and indicators, showing the velocity, resistance and cleaning efficiency of the Reed system. There will further be an exhibit of special compressor filters and high pressure filters suitable for cleaning and drying air under pressure.

Booth No. 151

William Swindell & Brothers
Pittsburgh, Pa.

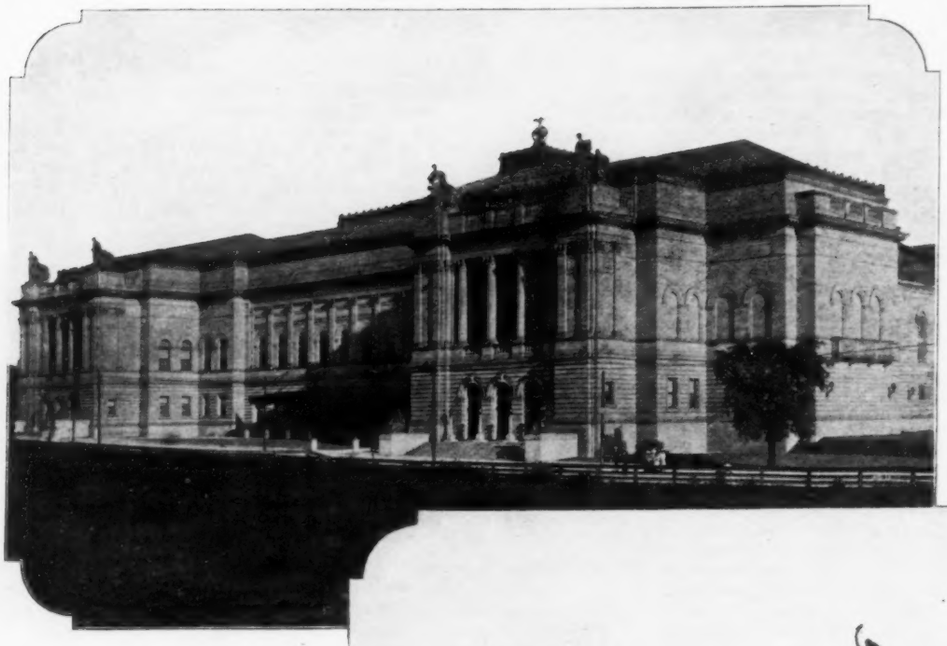
William Swindell & Brothers, Pittsburgh, Pa., will show representative installations of its line of electric furnaces. Arc type melting furnaces for iron and steel will be shown including both the single type and the multiple type, the latter being the newest development in the electric melting field. Electric heat treating and annealing furnaces of various forms will be shown. These are of the metallic resistor type equipped with automatic temperature control.

The exhibit will be in charge of: F. W. Brooke, W. H. Cosgrove, E. A. Hanff, R. W. Porter and E. H. Swindell.

Booth No. 55

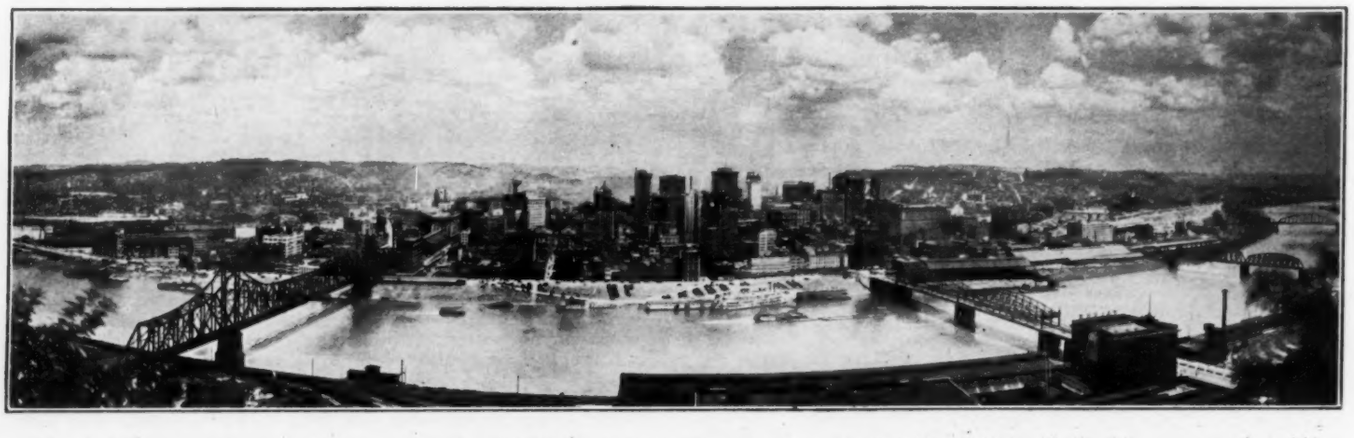
Stroh Steel-Hardening Process Company
Pittsburgh, Pa.

This firm covers an extensive range of manufacture having diversified clientele in blooming mills, rolling mills, cement, lime and brick plants, mines and collieries, foundries, industrial works, quarries and gravel pits. This makes it possible to exhibit only a limited application of the Stroh Process which is a method for casting the finest alloy steel together with ordinary soft steel in one solid piece. The resultant casting has a wearproof alloy steel stratum upon the wearing surfaces, while the body is composed of any desired steel and is in no way affected. The hammer formed and hammer finished crane track wheels exhibited have the flanges and tread of Stroh Alloy giving over four times the life of other wheels, the flanges cannot break and the tread



The magnificent Carnegie Institute where are housed a library of 500,000 volumes, the fourth largest museum in the world and a music hall with a seating capacity of 2,000.

Entrance to Highland Park, one of Pittsburgh's 24 public parks, with a combined area of 1,600 acres. It offers a remarkable view of the miles of plants lining the banks of the Allegheny River.



View of downtown Pittsburgh from Grandview Avenue, Mt. Washington.

will not peel off; an attractive booklet is issued showing Standard Crane Track Wheel data.

Some of the special castings are crusher rolls, cement mill master gears, shear knives, coupling boxes, mill guides, mill spindles, sheaves, cams and tappets, wabblers, pushers, liner plates, dredge tumblers, and ladder rolls. Greater service per unit of cost is the unvarying guarantee of the Stroh Company. C. W. Hays, secretary; R. F. Crump, engineer, and K. G. White, advertising manager, will be found at the booth.

Booth No. 152

Axwell Equipment Company
Pittsburgh, Pa.

The Thermoid Rubber Company of Trenton, N. J., will occupy Booth No. 152 with a most unusual display of brake blocks, brake and clutch discs and various types of friction facings.

They will also show the new thermoid flexible coupling which is becoming most popular for mill and mine equipment. Several of the large Pittsburgh industries are using this coupling with great success.

J. N. Bills, factory representative of the Thermoid Rubber Company, and J. L. Cadwallader, sales manager of the Axwell Equipment Company, 240 Second Avenue, Pittsburgh, who represent the Thermoid Company locally, will be in charge of the Thermoid Booth.

Booth No. 83

The Edison Storage Battery Company

The Edison Storage Battery Company exhibit at Booth 83 is designed to illustrate the use of Edison equipped industrial trucks and tractors in the iron and steel industry.

The main exhibit is a large colored photograph of an Edison equipped crucible truck. The intense heat from the furnaces and molten metal has no effect on the life of the Edison battery. A portrait of Thomas A. Edison, inventor of the steel alkaline storage battery and president of the Edison Storage Battery Company, is at the left of this photo, while at the right is a parts exhibit board showing the complete assembly of the Edison battery.

A 24 cell A8 battery, as used in industrial trucks, completes the exhibit. Literature on the construction and use of the Edison Steel Alkaline Batteries, is available for free distribution to those interested in reducing the cost of material handling in their plants.

Mr. J. K. Mahaffey, district manager, is in charge of the booth.

Booths Nos. 62 and 63

Rutherfoord & Uptegraff
Pittsburgh, Pa.

These well-known manufacturing agents will have on display and, wherever practical, in operation, the latest designs of certain items of equipment, typifying the products of the various factories which they represent. Commencing with the Weston Electrical Instrument Company's latest contribution to the power station industry, the rectangular instruments, these will be in actual operation, and visitors may judge of their many outstanding characteristics. They will also show many other Weston instruments, for both portable and switchboard use. The Sundh Electric Company, through the same sales agents, will exhibit (in operation) one of their automatic control panels for slip ring motor.

Rutherfoord & Uptegraff, who have for several years represented the well known line of graphic recording instruments of the Esterline-Angus Company, will have one or more of them in operation. These will be of the latest design, which embody many special features that will be of much interest to users; for example, removable ink well, wide damping range, etc. The Wilmington Fibre Specialty Company, through these selling agents, will have on display samples of their rods, sheets and tubes. Manual control of electrical equipment will be well exemplified through the exhibit (in operation) by the Union Electric Mfg. Company of Milwaukee, also by other samples of their product.

In this exhibit, Rutherfoord & Uptegraff have carried through their idea for showing their exhibit "in action" wherever it has been practical to do this, and no doubt visitors will not fail to appreciate the full value of this idea.

In co-operation with the above exhibitors, an exhibit of Howell Red Band motors will be made by the Howell Electric Motors Company. A squirrel cage induction motor, equipped with roller bearings, will be exhibited, showing the general design.

Booths Nos. 100-109

Westinghouse Electric & Mfg. Company
East Pittsburgh, Pa.

This company will have on exhibit at their booths an entirely new line of d.c. magnetic controllers, designed especially for heavy duty steel mill service. The latest design of type C form BB magnetic controller, which is devised for plugging service, will be connected to an 80-hp. type MC motor and controlled by a new type of foot-operated master switch. This will be shown in actual operation. A type C form MB controller, which is a new form, will be shown with the latest design of two-point master switch.

The new design type C form DD controller, which provides dynamic braking in the off position, will be exhibited in operation with the new design of four-point master switch in connection with an 80-hp. type MC motor. The new type C form EE controller, which is for hoist duty with dynamic braking lowering, will be shown on the exhibition floor with its latest design of crane hoist master switch.

A new form of controller, known as the type C form MD, will be exhibited for the first time with the latest form of type MM or "pan cake" master switch. This is a non-reversing type of controller which provides dynamic braking in the off position.

The controller exhibit will be completed with a display of the latest design of crane protective panel, which includes some new and exclusive protective features.

Several different sizes of the well known type CS motor will be shown. Several improvements that increase reliability are included.

An interesting feature of the exhibit will be a demonstration outfit which will show type LV lightning arresters in actual operation. Miniature lightning discharges will be produced and the demonstration outfit will show how the excess line voltages produced by these discharges are dissipated by the arrester. A large type SV arrester will also be shown.

Micarta, the material of endless possibilities, will be displayed in such a way as to show some of the many forms in which it can be produced.

Safety knife switches will be shown in many forms and capacities. A heavy duty type, with new design arc quenchers, being built especially for steel mill service, will be of interest.

A number 2 MDA turbine and a 7½-kw. turbine generator will show the latest advances made in the steam turbine field.

All the d.c. power used by exhibitors will be furnished from a 300-kw. Westinghouse automatic sub-station. The Duquesne Light Company is furnishing 2200-volt, 3-phase, 60-cycle power from a transformer sub-station outside the exhibition hall to the 432-hp., 1200-rpm. motor which drives the generator. The switching equipment is of the full automatic type, protecting the motor generator against all kinds of overload or overheating and shutting down the outfit when there is no demand for current.

In attendance will be Messrs. B. Wiley, E. A. Hurme, P. McShane, G. E. Stoltz, F. R. Burt, R. O. Watson, O. Needham, Carl Taylor, J. T. Peden, J. H. Overpeck, R. H. Ellis, R. W. Leech, L. R. Botsai, R. A. Neal, E. H. Ott, G. A. Brown, W. L. Newmeyer and D. H. Hunter.

Booth No. 14

The Tool Steel Gear & Pinion Company
Cincinnati, Ohio

Tool steel quality gears, pinions, sprockets, cranes, track wheels, steel bushings, coke crushers, segments, etc., will be shown. This company is making a special feature of helical gears and pinions, wisdom tooth pinions, leveler rolls, and mill pinions with hardened wabblers.

Those who expect to be in attendance are: Messrs. C. E. Sawtelle, E. S. Sawtelle, J. P. Biggert, P. H. Conroy, W. H. Evans and H. G. Ross.

Booths Nos. 91 and 92

H. Lee Reynolds Company
Pittsburgh, Pa.

This company's combined booths are among the most attractive at the exposition. The gateway arch is made by the Union Metal Manufacturing Company. The columns are of rust resisting sheet steel. Across the back of these two booths

is an attractive rose screen, which is also a product of the above mentioned company and is composed of Union Metal columns and a wood trellis.

The other products displayed are Mercury storage battery tractors and trailers made by the Mercury Manufacturing Company of Chicago, a high lift electric truck made by the Eleveyor Industrial Truck Corporation of Brooklyn, N. Y., and some attractive lighting standards made by the Union Metal Manufacturing Company and lighting equipment made by the General Electric Company. Besides this there is a large sample board of Salamander fireproof wires and cables, a product of the York Insulated Wire Works.

This exhibit will be especially interesting to architects and lighting engineers, as well as to operating engineers seeking the most economical method of material handling.

Information will be gladly given concerning these various products by W. A. Schertz, R. P. Miller, H. Lee Reynolds and J. R. Lewis.

Booth No. 46

Electric Storage Battery Company

This company, makers of Exide batteries, will have an interesting exhibit. The display will feature several oil paintings or shadow boxes and a small painted bulletin board fashioned from their regular outdoor bulletin board which appears in all parts of the country. There will also be cutaway batteries of the Exide Ironclad type as well as the Hycap or flat plate type.

Displays of the Exide Ironclad cells for industrial truck and tractor service and also for use in mine locomotives will be shown and may be examined by those interested. One of the giant Exide Ironclad cells for use in industrial storage battery locomotives will also be shown. This is the largest battery of its kind, being almost as large as those used in submarines. An added attraction at the Exide booth will be the display of the complete line of improved radio batteries now being made by this company.

The six-volt Exide "A" battery, with its new mono-block composition construction, presents to the radio world what is without doubt the most attractive radio battery on the market. There are also two low voltage "A" batteries for use with small tubes.

Two new "B" batteries and a chemical rectifier have been added since last year. The 24-volt rubber case "B" battery, which combines exceptional compactness with large capacity, will be shown. The two new "B" batteries are of the glass cell type with perhaps the greatest capacity of any "B" batteries obtainable. This type is shown in both the 24-volt and 48-volt units. The chemical rectifier is used for charging "B" batteries and small "A" batteries and also represents an improvement over existing types.

Competent men will be on hand to explain the many applications of the storage battery in the iron and steel and allied industries. The following will be inattendance: Messrs. Wm. C. Van Brandt, R. A. Whetstone, Jr., C. P. Sidwell, H. W. Bevins, M. H. Cokefair, W. E. Kirk, H. L. Kirk, J. L. Boyle, Arthur Bing, C. A. Frost, H. E. Eirhart and Roy Varney.

Booth No. 133

Vulcan Soot Cleaner Company

The valve operating soot blower head will be exhibited in this booth, which will be in charge of Mr. Fred W. Linaker, vice president of the Vulcan Soot Cleaner Company, together with Mr. Jno. D. Hiles and Mr. Short of the Jno. D. Hiles Company, their Pittsburgh representatives.

The Vulcan self-contained soot blower head differs from all others in that the valve is an integral part of the head and is closely associated with the cleaner element, so that the valve and rotatable element are operated by one operating handle or one chain. The valve disc portion consists of a swinging valve disc. It is self-grinding, positive in action and cannot be held away from the seat by any dirt or grit on either the seat or the disc. It can be seen in actual service on the largest horizontal water tube boiler in the world (the 3,000-hp. boiler in the Cecil Plant of the Allegheny County Steam Heating Company, Pittsburgh, Pa.).

Booth No. 47

The Calorizing Company
Pittsburgh, Pa.

This company, manufacturers of heat enduring and saving equipment, will exhibit the following material: Calorized steel annealing box, and Calorized steel lead pot, with only one half treated so that the other half has scaled in the fire. Their heat enduring alloy will be illustrated with such parts as furnace skid rails for continuous billet heating furnaces, I-beams and carbonizing boxes. A small Calco recuperator attached to a furnace under heat will illustrate this device for saving most of the heat of the waste gases. This unit is made of Calorized steel tubes, and the degree of preheat of the air will be plainly shown.

The representative who will be present at the exhibition will be Messrs. B. J. Sayles, A. R. Knight, H. D. Miller and Roger Stuart Brown.

Booth No. 52

Trumbull Electric Mfg. Company
Plainville, Conn.

This company will show representative samples of the well known "Circle T" safety switches. This line is particularly well suited for steel mill and other heavy industrial applications, the switches being 100 per cent Type "A" and mounted in safety cabinets. Sizes range from 30-amp. to 1200-amp., all poles and voltages up to 600 volts a.c. The 600-volt type is equipped with special patented arc-snuffers.

In addition to the regular line, several specialties will also be exhibited, among which will be motor-starting switches with overload relays and undervoltage protection, and a new line of 30-amp. rotary movement safety switches. The latter is built in a very compact design to fill the demand for fractional motor and heavy lighting circuit control.

Numerous refinements and changes in detail have been recently incorporated in the Trumbull switches, resulting in an established standard design to conform to the demands of the trade. The complete catalog of both open and enclosed types of switches has been recently revised and is now nearly ready for distribution.

A. H. Bergendahl, salesman in the Pittsburgh district, and C. E. Hanny, sales engineer from the factory, will be in attendance.

Booth No. 75

Johns-Manville, Inc.
Chicago, Ill.

This company will display samples of various forms of insulation, roofings, waterproofing, electrical and power specialty materials, and possibly some new forms of high heat insulation.

Personnel to be on hand will include: Messrs. Eugene Dowling, Howard Dowling, D. Very, T. K. Mial, J. S. Charles, E. W. Rosenberger, G. V. Fleck and G. A. Mark.

Booth No. 160

The Sharples Specialty Company
Philadelphia, Pa.

This company of centrifugal engineers, who manufacture the well known high speed Sharples super centrifuge, that is used for a great variety of purposes in the industries for the removal of finely divided solids from liquids and for the breaking of emulsions, will be represented by their Pittsburgh representative, Mr. Charles T. Dabney, and his assistant, Mr. Blake D. Hay.

The Sharples Specialty Company will have on hand detailed description of their apparatus and will have commercial models of their portable unit for dehydrating transformer and switch oils and stationary models that are used for the reclaiming of the lubricating oil of prime movers of all types.

The Sharples super centrifuges make use of the difference in specific gravity of the suspended solid material and water that contaminates lubricating oil when the oil is put into service. The rotor of the Sharples super centrifuge develops a centrifugal force equal to approximately 15,000 times that of gravity and makes possible the rapid and positive elimination of impurities from lubricating oil. Briefly, the idea is to take any prime mover or units of prime movers and connect the lubricating oil system up to that of the super centrifuge, bypassing a given amount of the oil that is in circulation every hour to the super centrifuge. This continual elimination of the impurities in lubricating oil maintains it at its highest efficiency, keeps the piping system free from sludge and scale and effects important economies in reducing maintenance and lubricating oil consumption.

Among the many problems which the Pittsburgh representative, Mr. Dabney, is quite capable of discussing with visiting engineers are problems of lubrication of blooming mill engines, rolling mill engines, blast furnace gas engines, Diesel engines of all types, Unaflow steam engines of all types; in fact, all types of prime movers that are lubricated on the continuous system. Visiting engineers are requested to discuss any problem involving the reclaiming of lubricating oils and insulating oils.

Booth 77

The National Electric Mfg. Company
Pittsburgh, Pa.

In its booth this company shows a remarkable type of electric hammer-drill. Unlike other tools, the Syntron electric hammer is operated, not by a motor, but by a new application of electro magnets. Through a control box of unique design, coils on either end of the piston barrel are alternately energized. The piston, by magnetic attraction, is drawn to and fro within the barrel. The speed of the piston movement is the same as the frequency of the alternating current being used. The use of this principle, it is claimed, results in the following advantages:

No. 1—There is only one moving part, the piston. All motors, gears, eccentrics and other complicated mechanism are eliminated. There is nothing to get out of order. No. 2—The tool is portable and light; its size and weight are out of all usual proportion to its power. No. 3—The hammer cannot be stalled or overloaded; it will not burn out. No. 4—The hammer can be operated from any electric lamp socket; just plug it in. No. 5—The current consumption is no more than is needed for the ordinary electric flat iron.

It has been found that the Syntron can be used to especial advantage in masonry drilling and chipping, vibrating or wherever the rapid, measured blows of a hammer are needed. Its speed is said to be from 10 to 15 times that of hand work.

These points are proved by actual drilling and chipping test in the company's booth. The mechanical principle of the tool is also shown in an interesting section display. In addition to Mr. Weyandt, vice president and chief engineer, and Mr. E. D. Jackson, general manager, other representatives of the company will be in attendance.

Booth 39

Bacharach Industrial Instrument Company
Pittsburgh, Pa.

To assist the combustion engineer in his efforts to produce good uniform material with a minimum amount of fuel, many different kinds of industrial instruments have been designed and are being manufactured. The efforts of this company have been to manufacture industrial instruments which will produce the desired results dependably and with the least amount of attention. A number of these instruments will be exhibited and will include the Hydro Low Pressure Recorder for measuring gas and air pressure; the Hydro Volume Meter for recording flows of gas and air; the Hydro Pressure Volume Recorder for convenient comparison of volume and pressure; the Bacharach Manometers for indicating pressures and volumes of gas and air; the Universal Draft Indicator for measuring low pressures on a magnified scale; Pitot tubes and orifies to meet almost any conditions; Bacharach Electric CO_2 and CO meters for controlling combustion and furnace atmosphere; the Maihak Engine Indicator for setting valves and determining power of reciprocating engines, including the internal combustion class; the Bacharach Pyrometers for controlling temperatures, and Standco Megohmers for measuring electrical leaks through insulation. If any of the instruments should attract your interest and additional information should be wanted, ask anyone in attendance at the booth.

Those in attendance will include Messrs. E. J. Strauss, J. A. Stein and L. Vayda.

Booth No. 86

Westinghouse Lamp Company

This exhibit will consist of a complete line of incandescent lamps used for lighting industrial establishments and iron and steel mills. Some of these exhibits will show in a very interesting manner lighting effects obtained under clear and frosted lamps. Shadow effects and the ruggedness of particular types of incandescent lamp, where subject to extreme vibration, will also be featured. Industrial types of reflectors will be shown and the process of manufacture of these reflectors will be detailed so that anyone can see the thoroughness and attention given to each detail in the manufacture of the standard types of reflectors. The display will also show illustration of numerous installations made under the direction of the Illuminating Bureau of the Westinghouse Companies with samples of complete specifications submitted to users of Westinghouse Mazda lamps. Illumination testing devices, such as the foot-candle meter, will also be shown and demonstrated. Mr. Frank C. Barrington, district manager of Pittsburgh territory, will have charge of the exhibit, which will also be attended by Mr. A. B. Marshall of the Sales Promotion Service, New York office, and Mr. A. U. Ross of the Pittsburgh office.

Booth No. 40

Corliss Carbon Company
Bradford, Pa.

This company will show samples of different grades of carbon brushes, emphasizing especially the grades for series motors of the crane and mill types. There will also be shown samples of used brushes to give an indication of the brush face obtained after severe usage. One interesting exhibit will be a display of the various steps in the process of manufacturing carbon brushes, from raw materials to finished product. This shows the raw materials, such as pitch, graphite and coke; carbon flour, "green" plates, baked plates, annealed (graphitized) plates, and the different steps in finishing brushes. In addition there will be photographs of miscellaneous brush applications of certain brush making and finishing equipment in the Corliss plant.

Booth No. 10

The Nichols-Lintern Company
Cleveland, Ohio

This company will exhibit the improved Lintern Electro Magnetic Sander, which is now furnished with a heated air chamber which provides that the condition of the sand will be such that it will respond quickly and easily. They will also exhibit their new line of Universal signal lanterns, which they feel is complete, and that there is a Universal for every need.

Mr. A. R. Lintern, Mr. H. A. Pharo and Mr. Wm. Lintern, Jr., will be in attendance.

Booths Nos. 74 and 75

Cutler-Hammer Manufacturing Company

This company is placing before the steel mill electrical engineers attending the convention a new reversing full magnetic mill controller of the inductive time limit type. The functions of the controller on exhibition are being fully demonstrated in connection with a Crocker-Wheeler 25-hp., 220-volt, d.c. motor. A flywheel and friction load is provided to simulate the load characteristics of a roll table. Meters are provided for indicating currents taken by motor under varying accelerating conditions. The controller is of exceptional interest in that time limit acceleration is provided without the use of dashpots or electro-mechanical devices and auxiliary contacts have been practially eliminated. The exhibit controller, which is of standard design, shows clearly a simplicity of construction that has not heretofore been obtained with this type of control apparatus for steel mill operation.

The exhibit will be in charge of Mr. Frank Russell, of the company's engineering staff at Milwaukee. He will be assisted by Messrs. T. S. Towle, E. G. Peterson, E. J. Gove and B. L. Donahue, all of Pittsburgh.

Booths Nos. 36, 37 and 38

Duquesne Light Company and West Penn Power Company

"Live in and Expand Your Business in Greater Pittsburgh." The growth of the Pittsburgh District has been closely connected with the development and expansion of its public utility companies furnishing light and power. That these companies may more ably serve the district and be ready to meet the increased demands of this great community rapidly growing greater, power stations are constantly being enlarged, new equipment purchased and more lines and cables laid for the distribution. All along the line additional equipment is being installed as the scope of the service broadens.

In order that the visiting officials, engineers and their friends attending the Iron and Steel Exposition at the Duquesne Gardens, Pittsburgh, Pa., may more fully realize the magnitude of the service being rendered one of the largest

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A. R. LINTERN, Secretary,
Cleveland Section A. I. & S. E. E.

LINN O. MORROW, Secretary,
Philadelphia Section A. I. & S. E. E.

W. H. WILLIAMS, Secretary,
Chicago Section A. I. & S. E. E.

Facts Concerning the Convention City

PITTSBURGH:

Is the center of an area in which 60,000,000 people live.

And the territory within a night's ride does 75 per cent of the business of the country.

Purchasing power is nearly a billion a month.

Annually manufactures products worth $2,500,000,000.

Has a per capita wealth of $2,580, leading the rest of the United States.

Has the largest tube and pipe mill in the world.

Has the largest structural steel plant in the world.

Has the greatest wire manufacturing plant known.

Has the largest glass manufacturing plant in the world.

Has the largest independent concern making steel for bridges and construction.

Has one plant which leads the world in manufacturing air-brakes.

Has the world's largest corporation making rolling mill machinery.

Has the largest commercial coal plant in the United States.

Has the largest aluminum finishing works in the world.

Leads both hemispheres in the scope of its pickling and preserving plants.

Is an acknowledged center for scientific industrial research.

Leads the world in production of vanadium and radium.

Has the largest electrical manufacturing works in the world.

Has the world's largest cork manufacturing plant.

Leads the world in production of iron, steel, glass, electrical machinery, steel cars, tinplate, air brakes, railway signal and safety devices, fire brick, white lead and many other products—besides occupying a prominent place in the manufacture of 300 other products.

Stockyards rank sixth in the country in volume of business.

Ranks high in the manufacture of acids and other chemicals used in manufacturing.

Has the largest jack manufacturing plant in the United States.

Has one of the country's largest concerns building small boats—boats celebrated throughout the world.

Is a world center for plumbing supplies.

Has a warehouse covering 23 acres which is the largest in the world.

Has a river tonnage greater than the world's four largest ports combined.

Makes 40 per cent of the country's steel and produces more than that percentage of its coal and coke.

Has a banking surplus exceeded only by New York and Philadelphia.

Has a trust company which has the largest undivided surplus of any bank in the world, with one exception; it is double that of the Bank of England, three times that of the Imperial Bank of Germany and nearly quadruples that of the Bank of France (before and after the war).

Is a veritable home of art and music, as its sculptors and painters and composers have proven in competition with the world's masters.

By the late Professor Langley — conceived and constructed the first areoplane.

Has the largest photographic telescope and leads in the manufacture of telescopic lenses.

Has 700 churches, 20 hospitals, a score of modern theaters, hundreds of small theaters, excellent hotel accomodations, 50 clubs, 24 public parks with a combined area of 1,600 acres, and 600 miles of paved streets. The city is surrounded by 800 miles of finished roads, 55 playgrounds and vacation schools.

Has a "civic center," considered one of the most remarkable in the country, where are grouped the buildings of a dozen institutions, schools and organizations.

Boasts of two principal educational institutions, The University of Pittsburgh and the Carnegie Institute of Technology, having a registration of nearly 16,000 students from all over the world.

Has 140 grade schools, 7 four-year high schools, six junior high schools, 100 kindergartens and four normal schools for teachers. There are 72 parochial schools under direct control of the Roman Catholic Church, four colleges or universities of high rank for men or co-educational in their character, and one devoted exclusively to women, 15 preparatory schools, 10 business colleges, three theological seminaries, one library school, one school for the blind, large conservatory of music and the Mellon Institute of Research, an institution of international reputation connected with University of Pittsburgh.

Produces nearly one-third of the country's output of finished and rolled steel.

Produced 55 per cent of the steel that was used by the Allies to win the world war.

Has a capital exceeding a billion dollars invested in mills, blast furnaces and foundries.

Has 62 glass factories employing in normal times 25,000 workers at a yearly pay roll of $20,000,000, and these factories produce annually 10,000,000 boxes of glass with a total capital invested of $250,000,000.

Produces in plate glass alone 60,000,000 sq. ft. a year, which if made in one sheet would cover an area of 1,377 acres, or over two sq. miles.

Has the largest rail mill in the world, producing annually 100,000 tons of steel rails.

Has one of the largest electrical manufacturing plants in the world, employing 30,000 workers and producing annually electrical machinery valued at over $150,000,000.

Supplies with raw material the various industries of the United States in the following proportion:

Automobiles	40%
Hardware	47%
Agricultural implements	46%
Machinery	39%

Was the pioneer in natural gas development.

Has 40 miles of river front which form an almost uninterrupted line of manufacturing establishments.

Has 80 financial institutions, National Banks, State Banks and Trust Companies, and the resources of these banking institutions in October, 1921, were nearly one billion dollars.

The Savings Banks deposits amounted in 1921 to $323,000,000, or $2,710 per person.

The total bank clearings for the year 1920 represented the enormous sum of $8,982,887,399.

Floated past its doors on the Monongahela River in 1920 more than 24,000,000 tons of commerce—equal to the combined tonnage of the Suez, Panama and Kiel Canals. The tonnage created in the Pittsburgh District is greater than the combined tonnage of New York and Boston.

Has a railroad terminal system making it possible to handle more tonnage in this district than in any other district in America.

Railroad terminals handled during the month of October, 1920, 1,500,000 cars—350,000 cars in one week and 54,000 cars in one day.

Is the third largest produce distributing center in the United States.

Industries employ nearly 300,000 workmen with a daily pay roll of close to $2,000,000.00.

Is the only city in America which has an annual international exhibition of paintings.

District has within its confines 350 coal mines which employ 40,000 miners, and they produce annually over 100,000,000 tons of coal.

District produces three-fourths of the bituminous coal in Pennsylvania and more than 40 per cent of the entire output of the United States.

District produces annually over 20,000,000 tons of coke, or 50 per cent of the total production of this country.

District, including Connellsville, produces 75 per cent of the total coke output of this country.

EDITORIALS

(Continued from Page X)

heat and hot blast stoves of 75 to 80 per cent efficiency are being installed. However, the greatest fuel economies have been made possible by the use of internal combustion engines.

The other departments in the steel mill have also been the subject of considerable study for the combustion engineer and the open hearth and heating furnaces are beginning to show gratifying reductions in their fuel consumptions.

Here a woeful waste in fuel had been in practice for years, and the fuel savings possible were therefore all the greater.

The open hearth furnace, with its very high operating furnace temperature, resolves itself into a problem of waste heat reclamation. The answer has been regenerators, recuperators or waste heat boilers in which the heat is returned to the furnace or absorbed by a secondary medium. The problem of the heating furnace is a similar one, except to a lesser degree, since continuous furnaces have made possible a much greater absorption of heat in the main chamber and reduced the reclamation problem correspondingly. Great developments along these lines have already taken place and much improvement in fuel economies should be expected in these departments during the next few years.

The field of fuel conservation, combustion engineering or whatever it may be termed is a very broad one. When a new furnace is to be built the first step is the selection of the fuel which is to be used. The decision rests on availability and price. Once the fuel is determined its storage, preparation and introduction into the furnace must be considered. Means must be provided for supplying the air necessary for combustion. If high temperatures are required the necessary preheat for the air, the fuel or both, must be obtained. The design of the furnace must be such that a maximum of the heat generated in the combustion chamber will be absorbed by the metal being processed. The hot waste gases leaving the furnace proper must pass through some heat-reclaiming device in order to prevent an otherwise large stack loss.

Each step must be considered separately and then the whole tied together before the design of the finished equipment can be completed.

The combustion engineer has a big field to cover in efforts toward lower fuel bills, and with the ever-increasing cost of the various fuels the demands for such savings will be more and more insistent.

EXHIBITORS AND WHAT THEY WILL EXHIBIT

(Continued from Page 27)

industrial centers of the world, a joint exhibit of the Duquesne Light Company and the West Penn Power Company will be conducted. Statistical charts, maps, photographs and literature will be used showing and describing the interesting features of the systems. The application of central station service to almost every phase of industrial use may be viewed on the lines of these two companies, many of which will be shown at the booth. Arrangements can also be made while in Pittsburgh to visit any installation of central station service in which visiting engineers may be interested, particularly those in which the problem to be solved approximates that of the engineers' own problem. In addition an invitation is extended to all of those who may care to do so to personally inspect any or all of the plants and properties of the power companies.

Messrs. C. B. O'Donovan, G. W. Quentin and J. D. Hiles, Jr., will be in attendance for the Duquesne Light Company, and Messrs. T. Henderson, C. B. Rogers and H. S. Smiddy for the West Penn Power Company at the exposition.

STATEMENT OF OWNERSHIP, MANAGEMENT, ETC., OF

IRON AND STEEL ENGINEER

(Required by Act of Congress of August 24, 1912)

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Business Manager—John F. Kelly, Empire Bldg., Pittsburgh, Pa.

Names and addresses of stockholders holidng 1 per cent or more of total amount of stock: None.

Board of Directors

R. S. Shoemaker, President, American Rolling Mills, Middletown, Ohio.
A. C. Cummins, First Vice Pres., Carnegie Steel Co., Duquesne, Pa.
G. H. Schaeffer, Second Vice Pres., Carpenter Steel Co., Reading, Pa.
James Farrington, Treas., La Belle Iron Works, Steubenville, Ohio.
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H. E. Davis, Director, Interstate Iron & Steel Co., Chicago, Ill.
A. F. Jones, Director, Champion Machine & Forging Co., Cleveland, Ohio.
W. M. B. Connally, Director, Gulf States Steel Co., Alabama City, Ala.

Known bondholders, mortagees, and other security holders, holding 1 per cent or more of total amount of bonds, mortgages or other securities: None.

JOHN F. KELLY, Editor and Business Mgr.

Sworn to and subscribed before me this 25th day of March, 1924.

JOHN G. HOSICK, Notary Public.

(My commission expires March 7, 1925.)

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SEPTEMBER ISSUE

of

Iron and Steel Engineer

The articles appearing in this issue were prepared for presentation at our Nineteenth Annual Convention and Iron and Steel Exposition to be held in Pittsburgh, September 15th to 20th, 1924.

In the haste to have this issue printed, some errors and details may have been overlooked.

All papers will be printed in our 1924 Yearly Transactions and whatever corrections are to be made will appear at the time of reprinting. In addition to the reprints in the Yearly issue, all discussion will appear with the articles.

Whatever errors or corrections are to be made in these articles will be announced by the authors prior to the reading and discussion of their papers.

Developments in Electric Maintenance Shop Practice

By A. C. CUMMINS*

Introduction.

DURING the past three or four years no papers have been presented before the Association of Iron and Steel Electrical Engineers treating on the practical phases of motor repair shop practice. In this period there have been developments in certain features of design of electric steel mill equipment, and there has also been a corresponding development in the methods employed in steel mill shops for handling maintenance work. We hope that by treating the subject of shop practice in the form of a general discussion, with the expectation that every member will take part, verbally or in writing, that we will secure a fund of information on this subject which will be of great value to the membership.

We, therefore, are fowarding to every member of this Association and to all other electrical maintenance shops, an outline of the different operations usually carried on in steel mill shops with the request that they go over this matter carefully and come to the convention prepared to take part in this discussion or else assign someone in his organization to attend this meeting, and take part in the discussion. Discussion received by mail will be read at the meeting and will be greatly appreciated in case it is not possible for members to be present.

The points that seem most important in the proposed discussion are as follows:

First—General Motor Repair Shop Practice.

(a) Shop cleaning of equipment received for repairs. Best and most economical method.

(b) Inspection and test of equipment returned for repair; procedure and practice.

(c) Do you advocate running test of repaired equipment as final test.

(d) Has the apprentice system of training shop personnel proved satisfactory.

Second — Armature Repair Practice, D. C. Equipment.

(a) Should all armatures arriving at shop with one or more damaged coils be rewound, or should damaged coils be replaced without complete rewind? Have you any definite data on this subject?

(b) Should damaged commutators be repaired at mill shops, or is it more economical to return damaged commutator to manufacturer for repairs? What shop equipment is necessary for a good commutator job?

(c) What increased service has been obtained by the adoption of the dipping and baking process in treating armatures to give better insulating qualities? Have you any objections to the use of this process? Definite figures on this subject are very desirable.

(d) Have you adopted anything new to prevent breaking of armature leads in wire wound coils? What is best practice in reinforcing broken leads on armatures which give trouble in this respect?

(e) What is best practice in reference to shafts in regard to the following:

1. Bent shafts.
2. Worn journals.
3. Worn pinion fits.
4. Bad keyways.

(f) Commutators:

1. Do factory commutators prove sufficiently superior to justify the additional cost?
2. Do you advocate purchasing assembled bars or complete commutators mounted on bushings?
3. Do you know of any oil-proof paint or cement which will delay damage to commutator insulations caused by oil or grease?
4. Have you any application where undercutting does not seem practical?
5. Do high grade brushes bring any tangible returns in increased commutator life?

(g) What is best practice regarding bearings in the following details:

1. What is permissable radial wear in d.c. armatures?
2. What is permissable radial wear in induction motors ?
3. Have you found any quick way to inspect bearings for radial wear that is dependable?
4. In rebabbitting shells is it always necessary to first tin shells as recommended by manufacturers?
5. Do you use any special care in handling babbitt? If a change in babbitting has recently been made have you noted any superior service? Does pyrometer equipment actually enable babbitt men to do enough better work to justify the investment?
6. Do modern babbitt bearing designs eliminate oil from armatures? What does shop observe?

(h) What is best practice with anti-friction bearing in regard to the following:

1. Removal from shafts without damage?
2. What is their ultimate life? How should greasing be handled?
3. Do motors equipped with anti-friction bearings reach shop absolutely free of grease and oil on windings and commutators? More or less than latest babbitt bearing types?

(i) Coils.

1. Do you advocate electric shops equipping themselves to make their own coils? Let us hear your views on this subject?

*Electrical Superintendent, Carnegie Steel Company, Duquesne, Pa.

(j) Assuming you are using a dipping and baking process of varnishing armatures what is the best practice in handling the following details:

1. Cleaning after winding, but before drying.
2. Drying, before dipping.
3. Dipping, how immersed, and for how long?
4. Do you know of any special varnish characteristics which have proved specially desirable?
5. How should excess varnish be removed? Why should it be removed?
6. What are the most satisfactory baking temperatures and baking times?

Third — A. C. Stator Practice — Cores.

(a) When is restacking necessary? How may it be avoided?

(b) Best practice in preparing cores for winding?

(c) Are riveted laminations proving superior to older designs?

Winding, Practice.

(a) Insulation of slots.

(b) Coil insulation.

(c) Dipping and baking.

(d) Kinks.

Rotors.

(a) Is welding squirrel cage end rings to bars to old motors desirable?

(b) If so, are bars installed in slots bare, or is it best practice to use insulation as originally designed?

(c) In what way does shop practice in handling wound rotors differ from d.c. practice?

(d) Are there any reasons why dipping and baking are not desirable in wound rotors?

Fourth — Controllers.

(a) Should control be repaired by shop men or general mill maintainence men? Why? What is the extent of repair?

(b) If control is repaired in shop what provision is necessary for test and adjustment before storing as spare equipment?

(c) Should resistance be standardized? What steps have you taken to reduce the number of different grid sizes required?

(d) Have you any special "stunts" for handling control repairs?

Fifth — Final.

(a) How are shops to keep down investment in supplies? Some works have 50 per cent of their total electrical stores invested in armature coils. How can this be kept down?

(b) What proportion of running armatures should be stored as spares?

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*Power in the Iron and Steel Industry**

By BARTON R. SHOVER†

SECOND only in importance to the supply of raw materials for making iron and steel is power, whether human or mechanical, and the tendency of man to shirk physical labor together with the growing demand for the product and the increasing cost of fuel make the problem of mechanical power one of vital interest.

The following figures, taken from the Statistical Report of the American Iron & Steel Institute for 1922 upon which the power estimates are based, will impress even the uninitiated with the importance and amount of power required by this industry.

TABLE I.

	Production Net Tons	Capacity Tons
By-product coke	28,550,545*	
Other coke	8,573,467	
Total	37,124,012	
	Tons	
Pig iron	27,219,904	52,686,820
Ingots	34,568,418	58,644,655
Rolled Products		
Rails	2,171,776	
Plates	3,419,920	
Sheets	4,548,477	
Nail and spike bar	21,969	
Wire rods	2,654,741	
Structural shapes	2,718,768	
Merchant bars	4,554,474	
Skelp	2,859,095	
Hoops	222,139	
Bands and cotton ties	271,101	
Splice and tie plate bars	605,688	
Sheet piling	13,220	
Railroad ties	14,811	
Forging blooms	326,303	
Blooms, sheet bar, etc., exported	11,299	
All other rolled products	2,038,223	
Total	26,452,004 tons	

Average and Maximum Productions for the Ten Years 1913 to 1922.

Averages.

	Net Tons
Coke	44,699,261
Pig iron	31,317,464
Ingots	34,082,495
Rolled products	26,228,363

Maximum.

		Net Tons
Coke	1918	56,478,372
Pig iron	1916	39,434,797
Ingots	1917	43,619,200
Rolled products	1917	33,067,700

*Note: Throughout this paper "net tons" means 2,000 lbs. Unless otherwise specified, "tons" means 2240 lbs.

Professors Ely and Rittman of the Carnegie Institute have published certain findings in regard to the power requirements of the Pittsburgh District for the iron and steel industry, from which report the following average figures for the 10 years 1911 to 1920 are taken:

*Abstract of a paper presented at the first World Power Conference, held in London, England, June 30th to July 12th, 1924.

†Consulting Engineer, Pittsburgh, Pa.

TABLE II.

Annual production of steel ingots	11,980,000 tons
Coal or its equivalent used under boilers	7,095,000 "
Coal or its equivalent, per ton of ingots	.5922 "
Ratio of coal to blast furnace gas used	60 to 40
Coal per ton of ingots	.355
Blast furnace gas per ton of ingots	71,600 cu. ft.

In addition to the above, which covers coal used by the steel companies, the two public service companies in this district supplied a total of 140,100,000 kwh. for power only to the steel industry. Their average coal consumption was 1.68 pounds per kwh. delivered to the switchboard, which at the transmission efficiency used later in this paper in connection with "power requirements" would mean 1.84 pounds of coal per kwh. delivered to the customer.

	Tons
Coal per ton of ingots used by power companies	.0096
Coal per ton of ingots used by steel plants	.355
Total coal per ton of ingots in the Pittsburgh District for power purposes only	.3646

As practically all varieties of finished steel are made in the Pittsburgh District, whose output is nearly one-half of the total, it is fair to assume that the above figures are representative. On this basis the steel industry consumed, for power purposes only, more than 12,400,000 tons of coal per year for the average production, over 15,900,000 tons for maximum production, and should all plants operate to capacity, nearly 21,400,000 tons.

The last complete report of the United States Bureau of Census, which is for 1919, gives much interesting and valuable data in regard to this industry, and while it is to be regretted that later figures are not available, a comparison of those for 1919 with corresponding figures for 1909 gives an indication of the tendencies and some idea of present conditions. From these figures the following table has been prepared:

TABLE III

	Number of Power Units				Rated Horse Power			
	1909	1919	% Change Inc.	% Change Dec.	1909	1919	% Change Inc.	% Change Dec.
No. establishments	719	784	10.42	***				
Plant Power								
Steam	6,728	7,877	***	10	3,061,332	4,217,868	38	***
Internal combustion	208	287	38	***	208,077	542,920	161	***
Water	81	63	***	34	8,236	10,581	28	***
Total	7,017	8,227	***	5	3,277,698	4,770,489	46	***
Purchased Power								
Electric	2,795	25,350	807	***	76,695	804,170	948	***
Other		150	150		140	2,925	2117	***
Total	2,795	25,500	812	***	76,835	807,095	951	***
Total Primary Power	11,812	33,727	210	***	3,354,533	5,577,584	66	***
Electric from Plant Power	29,557	71,490	185	***	795,028	1,908,604	140	***
Total Electric	32,352	96,840	206	***	871,723	2,712,774	211	***
Used Direct					2,804,975	3,636,653	30	***
Total Applied Power					3,676,698	6,349,407	46	***
% Electric to Applied					24	43	80	***
% Direct to Applied					76	57	***	25

In the above table, "Number of Units" represents the number of engines or motors installed. "Rated Horse Power" represents the total rated hp. of the units irrespective of the amount of power, or hp. hours generated or used. "Other Power" is chiefly from line shafting extended from adjacent works.

From data collected by the Association of Iron & Steel Electrical Engineers for 1923, the ratio of the hp. of prime movers driving electric generators to the hp. of motors installed is .59 to 1. A study of the data submitted by different companies developed the fact that the more completely the plant is electrified, the higher is the ratio between generator and motor capacity; in other words, the better is the load factor of the motor installation. Some of the older plants where motors were used for cranes, tables, etc., only, had a ratio as low as 1 to 7.

The constantly increasing application of motors since 1909 means that the generator capacity for 1919 was less in proportion to the installed motor capacity than it was in 1923 and very materially less in 1909, but because no data is available for these years, the ratio for 1923 is used in arriving at the figures for "Direct Power", although there is no question but that the increase of direct power as shown is thus made considerably greater than was actually the case. "Other power" is assumed as being applied direct.

	1909	1919
Total plant power (hp.)	3,277,698	4,770,489
Used to drive electric generators	472,723	1,134,856
Direct power	2,804,975	3,636,633

"Direct power" also includes power used for driving air compressors and hydraulic pumps, but the total amount is relatively small and no data is available for its segregation.

Total "applied power" is the sum of "total electric" and "direct power".

The Association of Iron & Steel Electrical Engineers sent a questionnaire to all of its firm members requesting information in regard to their power equipment, etc., for the year 1923 and while some replies were not as complete as could be desired, the following summary of total figures gives a very good idea of the power situation:

TABLE IV.

	A.	B.	C.
Number of companies reporting	5	67	18
Rated capacity; pig iron; tons	1,022,250	20,180,740	....
Rated capacity; rolled products; tons	....	29,150,085	....
Rated capacity; castings; tons	....	....	884,280
Hp. capacity of boilers used for power	28,086	1,053,970	43,030
Bhp. hours produced	141,514,440	6,654,800,728	180,876,000
No. of engines driving reversing mills	....	70	....
Hp. rating of engines driving reversing mills	....	288,656	....
No. of engines driving non-reversing mills	....	395	....
Hp. rating of engines driving non-reversing mills	....	542,203	....
No. of engines driving auxiliary apparatus	36	2,744	102
Hp. rating of engines driving auxiliary apparatus	6,270	721,448	37,900
Kw. capacity of electric generators	6,366	531,831	22,030
Kwh. produced	22,030,600	2,033,854,653	86,860,590
Kwh. purchased	....	426,105,990	116,333,006
No. of motors driving reversing mills	....	8	....
Hp. rating of motors driving reversing mills	....	23,600	....
No. of motors driving non-reversing mills	....	497	....
Hp. rating of motors driving non-reversing mills	....	334,711	....
No. of a.c. motors driving auxiliary apparatus	....	7,382	847
Hp. rating of a.c. motors driving auxiliary apparatus	....	325,132	24,233
No. of d.c. motors driving auxiliary apparatus	313	36,228	4,304

Hp. rating of d.c. motors driving auxiliary apparatus	7,906	930,632	34,039
No. of plants using no steam for power, all power purchased as electricity	0	12	8

Figures in the three columns of the above table are representative of:

A. Merchant blast furnaces not connected with steel works or rolling mills.

B. Plants consisting of blast furnaces, steel works and rolling mills, plants having steel works and rolling mills and plants having rolling mills only.

C. Steel foundries not connected with blast furnaces, steel works or rolling mills.

While the questionnaire asked for production and a few companies gave that figure, the majority returned rated capacities, hence the figures given are neither capacity nor production, but are nearer the former than the latter.

The figures giving number and rating of engines driving auxiliary apparatus include blast furnace blowing engines.

Power Generation.

Table III shows that "Water" and "Other Power" are not used in sufficient amounts to be given consideration, and that practically all "Primary Power" generated in the plants comes either from steam or internal combustion engines.

While reciprocating engines still comprise the larger proportion of power units, the turbine is coming more and more into use. In 1909, the turbine was not considered of enough importance to be listed separately in the census report, but the 1919 report gives 955 units aggregating 893,884 hp. or 21 per cent of the total steam power listed. Two manufacturers of turbo-generators report records of 334 units of their make ranging in size from 300 kw. to 17,000 kw. and totaling 908,425 kw. as being in use in the iron and steel industry at the end of 1923. Of these units 66, totaling 357,375 kw. or 39 per cent have been installed since 1918.

The 160 per cent increase in the capacity of internal combustion engines shown in Table III would, alone, indicate a very radical tendency in that direction, but conditions have changed. The years 1905 to 1914 might be termed the "Gas Engine Era" in the development of steel works power, since the major portion of the total capacity was installed during that period.

Increase in speed, capacity and efficiency of the turbine together with its lessening cost per hp. have swung the tendency towards it, and close inquiry shows the installation of only five gas engine generating units aggregating 21,140 kw. capacity with no blowing units since 1918. This capacity compared with the 357,375 kw. turbo-generators previously mentioned as having been installed during the same period clearly shows which method of power generation is at present preferred. The advantage which the internal combustion engine has in regard to heat efficiency will probably bring it into favor again when fuel has advanced a certain amount in cost (apparently to about $10.00 per ton) particularly if the installation cost can be reduced and reliability increased, but until they occur the gas engine is not likely to be restored to favor in America.

It will be noted from Table III that while the increase in the total capacity of motors operated from plant power was 1,113,576 hp. or 140 per cent, the increase in capacity of motors operated from purchased power was 727,475 hp. or 949 per cent. The increase in capacity of motors operated from purchased power being so nearly equal to that of motors operated from plant power shows that purchased power must be considered as part of the power system, and this is further greatly emphasized by the difference in the rates of increase, indicating the tendency to depend more and more on electric power generated outside the works, principally by public service companies.

Table I shows that while some by-product fuel and waste heat is used for power generation, a large quantity of coal is consumed. That there is more than sufficient waste heat available for power alone in plants having coke ovens and blast furnaces is shown in the following calculations. These figures are general and some assumptions were necessary, but they are believed to be fair, also figures used for power requirements, efficiencies, etc., taken from the Association of Iron & Steel Electrical Engineers' charts are averages from actual practice, and the whole picture, together with the deductions, shows the possibilities of saving immense amounts of coal.

Assume that all power, except for blowing the blast furnaces, is applied electrically, that all steel is made in open hearth furnaces, and that all coke is made in by-product ovens. The tonnages of coke, pig, etc., are the United States production for 1922.

POWER REQUIREMENTS

	Net Tons	K.W.Hrs.
Coke	37,124,012	111,372,036
Pig iron	27,219,904	435,518,564
Ingots	34,568,418	241,978,926
Blooms	30,420,208	790,925,408
Billets	11,432,041	354,393,271
Sheet bar	5,228,131	245,722,198
Finished steel	26,452,004	2,359,293,524
Total		4,439,203,927
Call it		4,440,000,000

Above figures are for power delivered to the motors. A.c. power is transmitted direct or by long distance high tension lines with step-up and step-down transformers, and some of it is converted to d.c. Some power is generated and delivered as d.c.

To obtain coal requirements generation, transmission and conversion losses must be considered.

Assume.

All power generated a.c. by turbo-generators.

All power transmitted through high tension long-distance lines with step-up and step-down transformers.

Under the above assumptions, the losses will be at least as much as they are under actual conditions.

The "Power Chart" shows that 1.73 lbs. of coal will deliver 3115 btu. to the motors, therefore it will require 1.9 lbs. of coal to deliver 3412 btu. or 1 kwh. Call it 2 pounds.

$$\frac{4{,}440{,}000{,}000 \times 2}{2240} = 3{,}964{,}287 \text{ tons}$$

Call it 4,000,000 tons

This is, the coal equivalent of 4,000,000 tons should furnish all the power required for making the United States 1922 production of coke, pig and ingots, and rolling the ingots into finished product.

TOTAL COAL OR ITS EQUIVALENT

For all purposes except for making coke.

	Tons
Power	4,000,000
Ingots	9,644,589
Heating	3,060,896
Total coal required	16,705,485

Total waste heat in coal equivalent, for 1922 production.

Coke	12,993,404
Pig	7,893,772
Ingots	1,970,400
Total coal equivalent of waste heat	22,857,576
Total steel requirements	16,705,485
Excess	6,152,091

PRESENT PRACTICE

On the basis of Pittsburgh District for power only (from Table I).

	Tons
Coal or equivalent—34,568,418 × .5922	20,471,417
Waste heat equivalent — 40 per cent	8,188,567
Actual coal — 60 per cent	12,282,850

This would mean that on an average twice as much waste heat alone as should be required is used for power purposes, to say nothing of half as much again coal in addition, or a total of five times the calculated requirements, which offers a fertile field for the development of future economies.

Considerably more pig iron is made than is required for steel, also more coke than is used in blast furnaces, and although the waste heat estimated is there, the amount available for products necessary to produce the finished steel would be:

Average pig iron per ton of ingots—lbs.	1,340
$\frac{34,568,418 \times 1,340}{2,240}$ tons pig	20,679,321
Average coke per ton of pig—lbs.	2.100
20,679,231 × 1.05 Net tons	21,713,287
Pig not used for steel — tons	6,540,583
Coke not used for pig — net tons	15,410,725
	Tons coal
6,540.583 × .29	1,896,769
15,410,725 × .35	5,393,754
	7,290.523
Surplus as previously estimated	6,152,091
Deficiency	1,138,432

This means that while there is an excess of waste heat over the calculations for the entire industry, there is a slight deficit when finished steel and only the pig and coke necessary for its production are considered.

	Tons Coal
Coal per net ton of coke	1.34
37,124,612 × 1.34	49,746,980

"Mineral Resources" for 1921 states that in average years 106,250,000 tons of coal are required for the iron and steel industry, which is over twice the requirements shown above, not to count the equivalent of over 6,000,000 tons in the form of excess waste heat. This excess coal alone amounts to the entire estimated consumption for domestic purposes.

Coke ovens and blast furnaces operate continuously, whereas steel works and rolling mills are normally idle over the week-end, consequently about one-seventh of the waste heat from the principal sources is given off when there is no use for it by its largest consumers, which also means that even in the ideal plant there would probably be a shortage of power from waste heat during six days of the week. This condition can be met by interchanging electric power with the local public service company. The steel company would take a comparatively small average amount of power during the week, and over week-ends the public service company could shut down part of its capacity; thus in the final analysis, saving the waste heat from the coke ovens and blast furnaces during that period. There are at least three places where this arrangement is in force and two others where negotiations towards this end are now in progress.

Power Application.

Power is applied direct or through electricity, compressed air or hydraulic pressure, but the amount used by the two least is so small a percentage of the total that it can be neglected.

Direct Drive.

By direct drive is meant the operation of apparatus by the original prime mover, whether direct connected or operating through gears, belts, shafting, etc., and was the original method of mechanically operating iron and steel works machinery.

Gas Engines.

Because of its lack of overload capacity and inability to adapt itself to sudden changes in loads, the internal combustion engine is not suitable for driving roll trains or other apparatus of this character, but it is well adapted for driving the tubs of reciprocating blast furnace blowers.

Turbo-Blowers.

Due to lower first cost and convenience of operation, the turbo-blower has of late years made considerable headway and while it can show advantages in every respect over the reciprocating steam engine for blowing blast furnaces, the gas engine surpasses it in thermal efficiency, in fact there is still a question in spite of higher first costs and operating expense, as to which of the two types of blowing units will show the better returns on the investment required.

The first turbo-blower used for blast furnaces was installed in 1909 and up to date 53 such units have been installed for blowing blast furnaces and seven for Bessemer converters. There are also about 25 turbo-compressors in the iron and steel industry furnishing air at 100 pounds pressure or more. The popularity of this form of blowing unit is shown by the claim of one manufacturer that during the past five years out of a total of 22 blowing units installed at blast furnaces, 20 were of the turbo type, the remaining two being reciprocating steam engines. One large plant having reciprocating steam and gas engine has recently placed an order for six turbo-blowers to replace reciprocating steam blowers, and other similar changes are being given careful consideration.

Turbine Drive.

In 1914, a turbine was direct connected to a roll train, and although this outfit is still operating, it has

never been duplicated, consequently it can be assumed that the results of such drive are not satisfactory.

Electric Motors.

The first use of the electric motor in the steel industry in America reported to the Association of Iron & Steel Electrical Engineers was the installation of three small units in 1891.

A yield of 75 per cent for the finished tonnage shown in Table IV would require 38,866,780 tons of ingots, or 66 per cent of the total ingot capacity. As the data from which this table was prepared represents conditions in the entire industry, it would be fair to apply this ratio to motors, which would mean a total of over 1,900,000 hp. motor capacity driving auxiliary apparatus, a remarkable growth in 32 years.

While the motor was used for driving auxiliary apparatus in 1891, it was not until 1905 that the first application of motor drive was made to roll trains. This installation consisted of two 1500 hp., 125 rpm., d.c. motors on the No. 3 Rail Mill, Edgar Thomson Works of the Carnegie Steel Company, which motors are still giving excellent service.

The first mill of any size to be operated by a.c. motors was the Gary Works of the Indiana Steel Company, started up in January, 1909. This equipment consisted of two 2,000 hp., 214 rpm. motors driving two high 40 in. slow speed blooming mills through trains of gears, one 6,000 hp., 75 rpm. motor direct coupled to a 40-in. three high blooming mill, one 6,000 hp., 83 rpm.; one 6,000 hp., 88 rpm., and one 2,000 hp., 67 rpm., direct coupled to three high 28 in. rail mill roll trains. All these motors were 3-phase, 25-cycle, 6,600-volt, and up to March 1, 1924, have rolled 7,335,656 tons of rails.

Three electric manufacturing companies report having furnished a total of 914 motors over 300 hp. capacity and aggregating 954,410 hp. for driving non-reversing hot mills in steel works.

The first motor applied to a reversing mill in America was installed on the 36-in. slabbing mill at the South Works of the Illinois Steel Company in 1906 and this motor is still in operation. To date the three larger manufacturing companies have furnished a total of 50 reversing drives totaling 201,800 hp. and there are in addition a few such motors supplied by other makers.

While the number and capacity of reversing steam engines in use surpasses those figures for motors, the tendency is shown by the fact that since 1918 there has been a total of 19 reversing motors installed as compared with only two reversing steam engine drives.

It is not within the scope of this paper to argue the merits of the different kinds of power units, but the tendency towards the use of electric motors as opposed to steam engines is too marked to allow passing without notice. Mistakes were made in regard to the size in the early installations, some motors being too large and others too small, but sufficient data has now been collected so that there is no difficulty in accurately determining the proper size of a motor, provided the governing data are known.

Common practice is a good argument. In 1923, one electric manfacturing company furnished nine motors aggregating 27,650 hp. to replace existing steam engines driving roll trains, while two electric companies report having furnished a total of 47 motors aggregating 103,565 hp. for this purpose, and against this showing not a single motor driving roll trains has been replaced by any other kind of power. A number of steel officials who have been responsible for the installation of engine drives during the past decade have expressed themselves as regretting their decision, but no one remembers having heard of such a statement in regard to a motor.

Many theoretical calculations have been made, also some tests, which show that the thermal efficiency of the direct steam drive is equal or even superior to that of the motor, but such claims are based on test conditions. Factors such as tight, well insulated steam lines, proper valve setting, high vacuum, etc., are all assumed to be perfect, but they all can and do deteriorate in practice and usually little attention is given to them so long as the engine will run, consequently the thermal efficiency of the steam drive is seldom, if ever, maintained at the highest point. On the other hand, practically nothing can happen to the transmission lines, the motor or its equipment which would lower the efficiency and still allow operation, consequently the motor is always operating under test conditions.

Deductions.

From the data, estimates and general history of the art as outlined above, the following are deduced as the present, and probable future, tendency of power generation and application in the Iron and Steel Industry:

1. Electrification of all power driven apparatus except blast furnace blowers.
2. Substitution of turbo-blowers, or possibly gas engines, for reciprocating steam blowing engines.
3. Purchase of power requirements by plants which have no waste heat available.
4. Complete economical utilization of waste heat by means of turbo-generators for electric power generation, except where this heat can be used to better advantage for "process" or has a market value greater than its coal equivalent.
5. Interchange of electric power between plants generating power from waste heat and public service companies.

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*The Slagging Producer in Steel Works**

By K. HUESSENER†

THERE is hardly any dissent today among fuel engineers that the aim in every steel works should be to have coal enter the works at one point only, i. e., the coke ovens, and that the only four fuels should be tar, coke oven gas, blast furnace gas and coke producer gas. The ideal condition would be to utilize tar, coke oven and blast furnace gas in so economical a manner that it should be possible to discard not only all coal gas producers, but all auxiliary firing of any kind. In practice such a result can, however, only be obtained where the supply of coke oven and blast furnace gas is vastly in excess of the demand and where consequently at least at certain periods profuse bleeding of blast furnace gas takes place, thus defeating the very economy aimed for.

Gas Peaks.

The difficulty to be contended with is both the irregular supply of blast furnace gas and the greatly varying heat requirements of the works. The proper utilization of peaks of blast furnace gas has for some time past claimed the attention of fuel engineers, and whether the stoves or the boilers should be made the recipients of the peaks, is still a contested question. In this respect, A. G. Witting's discussion of H. C. Siebert's paper on "Economical Use of Fuel in the Steel Plant" (See the November, 1923 issue of Association of Iron and Steel Electrical Engineers) is extremely interesting. Mr. Witting shows that for a seven-furnace operation, the peaks of blast furnace gas amount to 35,460,000 cu. ft. per day, which peaks he considers a total loss unless adequate auxiliary firing is provided to utilize these peaks for the generation of constant loads. He advocates spending $232.50 per day in auxiliary oil firing, using 5-cent oil, and shows that by doing so he can effect a saving of $456.50 per day, obtaining a net gain of $224.00 per day. He very rightly advocates the use of expensive fuel oil rather than coal, for the reason that economical mixed firing of gas is generally conceded to be impossible. Now, at the Gary plant with seven furnaces in operation, the peaks naturally represent a lesser percentage of the total gas production than at smaller plants. At a two-furnace plant, the total production of at least one blast furnace must properly be considered as peaks, owing to the fact that one of the two furnaces will for longer or shorter periods be off blast (casting, changing of tuyeres, etc.) and not be producing any gas. In such a plant the boilers are really the only place where the gas can economically be used, with the result that at certain times (week-ends) gas will be bled, at others auxiliary firing be necessary.

It is quite evident that this state of affairs calls for an auxiliary supply of gas to properly equalize the difference between the supply of and the demand for heat. There is no flexibility in the supply of gas from the coke ovens, nor have ordinary coal gas or water gas producers sufficient flexibility to properly play this part of equalizing. On the other hand, the slagging producer with its almost limitless flexibility is admirably suited to this purpose.

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History.

Before entering on the description of the slagging producer, a few words as to its historical development will be of interest. The slagging producer must properly be called the forerunner of the coal gas producer. Ever since producer gas was first made, the disposal of the ash in the fuel offered the main difficulty. As far back as the forties of the nineteenth century, Ebelman in Germany operated the first slagging producer, using various metallurgical slags as flux in the same manner as limestone is used in the blast furnace. These first attempts, however, appear not to have been sufficiently successful, as the subsequent development of gas producers was for the next 50 or 60 years in the direction of preventing rather than assisting the fusion of the ash. The temperatures in a gas producer are high enough to bring about a fusion of the average fuel ash, but generally not high enough to make it liquid. It is for this reason that steam is blown into the fire zone of the ordinary gas producer in order to keep the temperature below the fusion point of ash. The slagging producer employs the opposite principle. Instead of lowering the temperature in the fire zone, it lowers the fusion point of the ash by adding suitable fluxes, and disposes of the ash as liquid slag. It is to the credit of Von Holt at Georgs-Marien Huette near Osnabruck that he took up the experiments again where Ebelman and others left off. He succeeded in developing a slagging producer, which is not only fully operative, but also in finding new methods of operation which make it a paying proposition. He started by equipping an ordinary stationary Duff type producer with a set of tuyeres and a bosh and hearth on the lines of an ordinary blast furnace. He found that this producer which ordinarily could deal with a maximum of 15 tons of coal per day, as a slagging producer had a normal capacity of 65 tons of coke per day with a peak capacity at the rate of 100 tons per day. He also found that by carefully choosing his fluxes and by the addition of scrap and some ore, he could produce up to 320 lbs. of iron per ton of coke without lowering the efficiency of the producer and that this iron could be made to contain high contents of phosphorous and manganese, which made it very valuable for open hearth and foundry purposes. His next step was to build a second producer of a normal capacity of 100 tons and a peak capacity of 300 tons of coke per day. When he found that the smoothness of operation was the same for the larger producer as for the first small experimental outfit, he proceeded to design a producer of a normal capacity of 200 tons per day and a maximum capacity of 600 tons per day, which represents today the largest type so far tried out.

Description.

As will be seen from Fig. 1, the general shape of a slagging producer is that of a small blast furnace, the only difference being that the shaft is cylindrical and considerably smaller. Owing to the fact that only direct reductions take place in a slagging producer and that indirect reductions ($2\,CO = C + CO_2$) must be avoided —the height of the fuel bed has to be restricted to from 10 to 12 ft., even with the largest type of producer. On the other hand, it is desirable to have a very gener-

ous space on top of the fuel bed for the reception of the large volumes of very hot gas. The area of the hearth is between .45 and .6 sq. ft. for every ton normal capacity per day. The shaft must be as wide as possible in order to reduce the velocity of the gas which determines the amount of dust carried out of the producer. For a 200-ton producer the diameter of the shaft is about 12 ft. between linings, the height of the shaft between 25 and 30 ft. The bosh which follows the design of the blast furnace has an angle of 65 to 70 deg. Contrary to the experience with blast furnaces, the lines on which the producers are built are of minor importance.

The whole producer is lined with firebrick, and the lower portion of the shaft shell is water cooled, spray

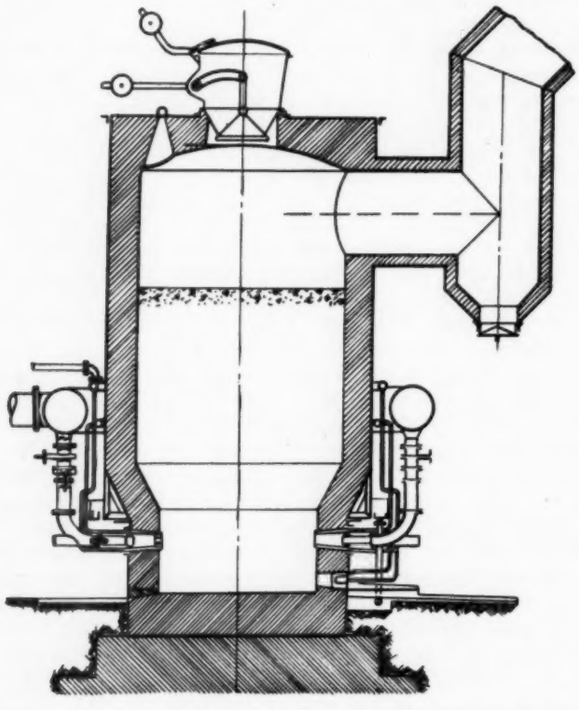

FIG. 1—*Diagrammatical cut through a slagging producer.*

cooling being usually resorted to. As the extent to which spray cooling is effective through fire bricks is usually not more than 6-in., the thickness of the lining of the lower portion is limited to this figure.

The hearth is equipped with a number of tuyeres which follow the design of blast furnace blow pipes. They have to be water cooled. A 200-ton producer will usually be equipped with eight 4-in. tuyeres through which the blast is supplied from a suitable blower. Slide valves, or for preference, automatic check valves between the bustle pipe and the tuyeres prevent the gas from entering the blast pipe. The gas is taken off at the top of the producer through one or more pipes and conducted to a dust catcher on the lines of the customary blast furnace dust catcher. The charging arrangement follows coal gas producer practice for the smaller type of slagging producer, whilst in the case of the larger types, 200 tons or over, ordinary skip hoists are used. The even distribution of fuel and a uniform height of fuel bed is of minor importance in slagging producers so that special tops as used for blast furnaces are not necessary.

Fuel.

Although blast furnace coke has so far proven the most suitable fuel, the slagging producer is not by any means confined to it. On the contrary, it can use a very wide range of fuels, dependent on the flexibility demanded from the producer. If the producer is to be used as an equalizer in blast furnace works, domestic coke ranging from ½-in. to 2-in. is the ideal fuel. Where domestic coke is of greater value than ordinary blast furnace coke, as is everywhere the case in Germany, ordinary blast furnace coke is used. In both cases, it is absolutely essential that the coke should be screened, or at least forked, as coke braize must be kept out of the producer on account of the fact that it is detrimental to the formation of an easy flowing slag and also causes hanging. As far as the use of coal, boiler ash and other waste fuels is concerned, the following rules can be laid down:

First—The contents and composition of the ash must be such that the weight of the slag does not amount to more than 90 to 95 per cent of the carbon in the fuel. This would in most cases render the use of fuels containing less than 62 per cent carbon impossible.

Second—Highly baking fuels cannot be used, nor can coal be used yielding a fluffy coke high in coke braize. The use of such coal would be paramount to adding coke braize to the charge, with the same detrimental effects.

Third—A uniform contents and composition of the ash is essential, as it determines the amount and composition of the fluxes.

In the case of bituminous fuels, there are mechanical difficulties in the disposal of the gas, such as high contents of dust and tarry matter which so far have rendered it impossible to operate a slagging producer on coal only, but very favorable results have been obtained by a mixture of 75 per cent coke and 25 per cent boiler coal. On the other hand, the admixture of coal, invariably causes an increase in dust and tarry matter, and it is at least doubtful whether this gas can be successfully passed through waste heat boilers in order to recover part of the very high amount of sensible heat, which as will be shown later, is essential in order to obtain a favorable thermal efficiency. No such difficulties are experienced by the use of boiler ashes, which can be very freely added to the coke, provided the total carbon contents of the charge is not reduced below 62 per cent. In Germany where boiler ashes are carefully separated from other refuse, quite a number of magnetic separators have been installed which prepare the ashes for use in boilers by eliminating those parts which contain no or little carbon and increase the percentage of combustibles in the remaining balance. Slagging producers have been quite successfully operated on this prepared boiler ash only. It will, however, readily be realized that the volume of slag would increase with the decrease of the heating value of the fuel and that the heat available for iron production will correspondingly decrease. At the same time, the flexibility of the producer which depends on the volume of slag carried, is bound to suffer if poor fuels are used.

Fluxes.

The smooth and easy operation of the slagging producer is dependent on an easy flowing and readily melting slag.

As in nearly all fuel ashes the acids (silicates, etc.) greatly exceed the alkalis (lime and manganese), the

resultant slag is too sluggish, should one attempt to operate the producer without fluxes. Contrary to blast furnace experience, limestone or lime are not suitable as a flux. In the first instance, the temperature in the camparatively short gasifying zone, where the reduction between ashes and limestone can only take place, is not high enough to fuse the limestone, secondly, on account of its high contents of CaO, the limestone would form such a small part of the charge that a really intimate mixture with the fuel could not be obtained. Suitable fluxes are blast furnace and open hearth slag, which contain the CaO in greatly diluted form and are also more easily reduced.

Where the fuel used is domestic or blast furnace coke, it is necessary as will be shown hereafter, to produce considerable quantities of iron in order to make a slagging producer a paying proposition. In this case the amount and nature of the fluxes and the analysis of the slag to be obtained strictly follow blast furnace practice. It has been found that a slag in accordance with the following formula:

$$(Si\ O_2 + Al_2\ O_3) \times .8 = (CaO + MgO)$$

is usually satisfactory. CaO can partially be substituted by FeO and MnO. Certain limy ores are quite suitable as fluxes, provided that the fine ore dust, which easily causes hanging, is not charged.

Gas.

It is one of the main advantages of the slagging producer that it produces gas of an astonishingly uniform composition and heating value quite independent of the rate of operation and the carbon contents of the fuel and the amount of iron produced. Where fuels containing a large percentage of volatiles are used, the contents of hydrogen and methane is a little larger, but it can be laid down as a general rule that slagging producer gas does not contain any CO_2, except such small quantities which may be driven off the fluxes and that the CO contents is always kept between 32½ and 33½ per cent. The following shows the range of composition of the gas from slagging producers using coke or other non-volatile fuels, being the range of 185 analyses:

	Per Cent
CO_2	.3 — .8
O_2	.0 — .1
CO	32.6 —33.4
H_2	2.0 — 2.3
CH_4	.12— .7

The hydrogen is solely derived in this case from the moisture in the air, the methane from the volatile in the coke. The net heating value of this type of gas is between 110 and 115 Btu.

A disadvantage is its high contents of dust which varies from .5 to 4 gr. per cu. ft., dependent on the physical qualities of the fuel and flux and on the rate of operation. The dust is highly acidous, as will be seen from the following typical analysis:

Fe	6.06
Mn	1.5
P	.26
S	1.72
SiO_2	14.01
Al_2O_3	2.33
CaO	4.48
MgO	1.31
C	57.95

and contains a very high amount of carbon. The gas is practically dry, as its only moisture contents is derived from the water in the coke. In order to dispose of the coarser particles of dust, it is necessary to pass the gas through a dust catcher. Most of the dust is, however, extremely fine, very much finer than blast furnace gas, so that it cannot be precipitated by reducing the rate of flow of the gas, on the other hand, it is readily washable to the same degree of cleanliness as blast furnace gas. Another disadvantage of this kind of gas, is its exrtemely high temperature of 1300 to 1400 deg. F., so that the sensible heat carried is equivalent to about 26 Btu. per cu. ft. and represents about 16 per cent of the heat value of the fuel. As in the majority of cases, the gas will have to be washed before it can be utilized, it is absolutely essential that at least part of the sensible heat is recovered by means of suitable waste heat boilers. In how far the financial returns of a slagging producer plant are influenced by waste heat boilers, will be shown later on.

Where dry hot cleaning of a blast furnace gas, such as electrical precipitation is used, the gas can be turned into the blast furnace gas main before it enters the precipitators. The result will, of course, be that the temperature of the blast furnace gas is increased, but as long as the temperature of the mixture is kept below the point where it detrimentally affects the electrical precipitation, waste heat boilers can be dispensed with and the total sensible heat be recovered as sensible heat in the mixture of blast furnace and producer gas. In adding slagging producer gas in greatly varying quantities to blast furnace gas, the result will naturally be a mixture of variable heat value, which may to a certain extent affect the conditions for perfect combustion. In most cases, however, by arranging the combustion of gas with an excess of air of 10 per cent, one will usually cover the whole range of possible heat values without any undue loss in efficiency. The gas is particularly suitable for operating gas engines after having been passed through a fine cleaning plant. On account of its high heating value, it will allow to drive gas engines, set for ordinary blast furnace gas, at a load from 10 to 20 per cent higher than rated. It is without any doubt a very desirable fuel for soaking pits and heating furnaces. As far as its use in open hearth furnaces is concerned, there is only one instance on record where this gas by itselt has been used for the operation of an open hearth furnace. Before that could be done, certain changes in the sizes of the gas regenerators were, however, necessary. One open hearth furnace was operated for six weeks on uncleaned hot slagging producer gas, and for the first five weeks the results were very satisfactory. Afterwards, the use of the gas had to be abandoned on account of the checker chambers being clogged up with the dust. Whilst there is no doubt that within the ranges of the possible preheating temperatures obtainable from open hearth regenerators, sufficiently high flame temperatures can be obtained to carry the required heats, to make it suitable for open hearth furnaces, the gas will have to be passed through at least a rough cleaning process. So far there is no practical experience available to show that an open hearth furnace can be operated on cold cleaned slagging producer gas. To draw a conclusion from the use of hot uncleaned gas is not permissible, for the reason that the dust which is extremely high in carbon may have given to the flame a luminosity, which it would not have when used cold and the lack of which might be the cause of failure. For this reason where it is desired to use slagging producer gas on open hearth furnaces, it should preferably be mixed with coke oven gas.

Operation.

The operation of a slagging producer is extremely simple, once the proper composition of the slag on the principles of blast furnace operation is assured, and care is taken to eliminate coke braize and ore dust. The charging of the properly weighed fuel and additions (flux, ores and scrap) watching of the tuyeres, flushing of slag and casting of iron, comprise all the necessary work. The blast is supplied by a suitable blower (positive or turbo blower) of variable speed, which if possible should be automatically governed so as to maintain a constant gas pressure at a suitable point of the gas main. The air requirements are about 50 to 52 cu. ft. and the gas produced 68 to 70 cu. ft. per pound of coke. The air pressure depends on the rate of blowing and the density of the charge. The blowers have to be arranged for a minimum pressure of ½ lb. and a maximum pressure of 3½ lbs. A 200-ton normal capacity producer at a maximum peak load of 600 tons must therefore be equipped with a blower capable of delivering a maximum of 45,000 C.F.M. of free air under a maximum pressure of 3½ lbs.

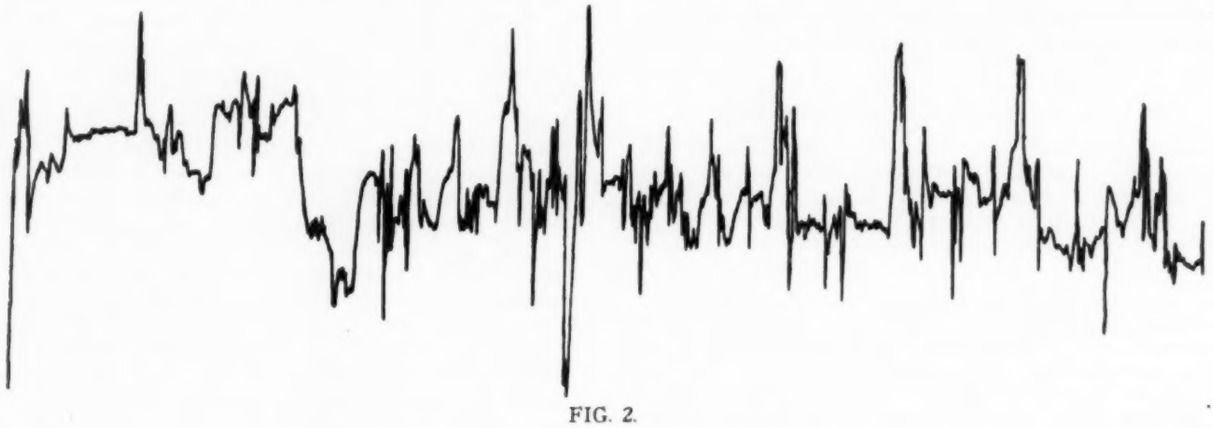

FIG. 2.

A feature which requires constant supervision, is that no matter how varying the load, the air blast must always penetrate to the center of the producer, as otherwise the combustion will not be uniform throughout the producer, with the result that the slag will freeze, forming a heap in the middle of the hearth which may grow to such an extent that the producers will have to be shut down. This condition may be met by inserting special linings into the tuyeres to reduce the nozzle area, or by blocking part of the tuyeres all together during slow operation.

The ever present danger of the formation of cold slag in the hearth makes it imperative to use the producer at least to a certain extent for the purpose of melting iron. It is immaterial whether the iron is charged as oxide or scrap, as the coke will reduce it anyway. The effect of the iron is as follows:

Owing to the low heat conductivity of the slag, there is always the danger of it not being kept hot, with the result that it will solidify. In order to avoid this, it is necessary to have at least small quantities of iron trickle through the slag. The iron passing through the gasifying zone becomes highly superheated and mixing with the slag imparts to it this superheat, which is enough to keep it liquid.

As to amount and composition of the iron which can be produced in a slagging producer, more will be said later. Suffice it to say here that the manufacture of iron in sufficient quantities to keep the slag liquid is a necessity for the successful operation of this type of producer. Where blast furnace slag is used as flux, the iron produced from this slag and from the ash of the coke will be sufficient. In most cases, however, it will be found that it will pay to use the producer far beyond this necessary range for the purpose of producing iron.

One of the main advantages of a slagging producer is its extreme flexibility:

The chart, (Fig. 2) shows the volume of wind blown, which of course, is proportionate to the quantity of gas. These charts were taken at a steel plant where a slagging producer is used to equalize the production of blast furnace gas and the chart shows how readily the rate of operation can be changed to suit requirements within extremely wide ranges. The rate of blowing does not in any way influence the composition of the gas, its only effect on the efficiency being that at a slower rate of operation, the gas temperature will drop, thus causing a certain loss in sensible heat.

Slagging Producer as a Blast Furnace.

In view of the fact that some production of pig iron is necessary for the smooth operation of the producer, it becomes immediately desirable to carry such production as far as possible without limiting the flexibility and the high rate of operation. The main difference between a slagging producer and the blast furnace is that the former uses cold blast and therefore works at considerably lower temperatures. Further, the height of the fuel bed is very much smaller, so that all reductions taking place are direct reductions ($CO_2 + C = 2\ CO$), and that the indirect reductions ($2\ CO = C + CO_2$) are entirely absent. This also accounts for the almost total absence of CO_2 in the gas. It is interesting to note that the reduction of ($CO_2 + C = 2CO$) which is objectionable for the blast furnace, as it prevents the carbon from reaching the hearth, is the very live nerve of the slagging producer.

To what extent a slagging producer can be used for the production of pig iron is not yet definitely known. The lower limit appears to be about 2 per cent of the coke charge whilst as much as 16 per cent have been regularly made without changing the quality of the iron or materially affecting the efficiency and flexibility of the producer. The actual upper limit is not yet known, but as will be seen from the tables given hereafter, it must lie considerably above 16 per cent, as the total heat used for reduction and absorbed by slag at this rate of production only amounts to 4.73 per cent of the heat in the coke. In this respect four tests made by Dr. Alfred

Wilhemi, to whom the writer is indebted for much of the information contained in this paper, are of great interest. These tests have been tabulated hereunder.

Table No. 1 shows the composition of the burden and the amount of iron and slag produced.

Notwithstanding the great changes in the operating conditions shown above, the thermal efficiency of the producer was hardly affected, as will be seen from Table No. 2 which gives the most important figures from the heat balance sheets of these four tests:

TABLE 1.—RELATION BETWEEN BURDEN AND IRON AND SLAG PRODUCTION.

Test	Percentage Charge Related to Coke						Lbs. iron produced per ton of coke	Lbs. of coke per ton of iron	Iron: Slag	Coke: Slag	% Iron of coke charge
	Minette Ore	Blast Fce. Slag	O.H. Slag	Other Ores	Lime-stone	Scrap					
1st	.....	50.0	....	....	....	...	50	89600	1:26	1:0.60	2.5
2nd	25.4%	26.4	....	....	5.2	...	196	22900	1:5.2	1:0.50	9.8
3rd	.....	22.0	....	23.5	23.5	...	184	24400	1:5.6	1:0.50	9.2
4th	.....	....	35.5	13.2	....	6.6	324	13850	1:2.3	1:0.37	16.2

TABLE 2.—THERMAL DISTRIBUTION

	1st	2nd	3rd	4th
Latent heat in gas.....	70.85	73.15	71.22	71.61
Sensible heat in gas.....	17.43	14.85	15.03	16.10
Total thermal efficiency.....	88.28	88.00	86.25	88.71
Heat used for reduction.....	.35	3.28	3.57	2.39
Heat in slag.....	3.62	3.05	3.13	2.34
Heat in cooling water.....	1.89	.85	1.92	2.09
Evaporation of water in charge	2.44	2.38	2.26	1.66
Radiation, etc.	3.42	2.44	2.87	2.81
	100.00	100.00	100.00	100.00

This table has been graphically reproduced in the chart shown in Fig. 3.

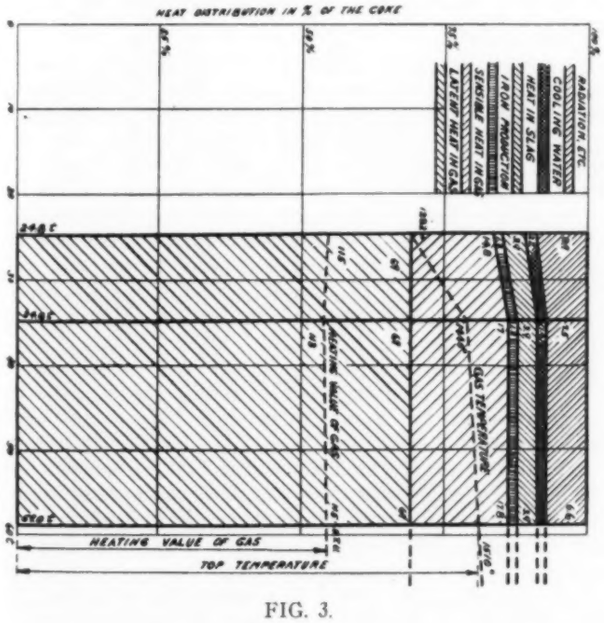

FIG. 3.

In order to show the quality of the iron and slag produced, Tables 3 and 4 are adduced:

As will be seen from these tables, the iron produced is very low in sulphur and except in Test No. 1, low in silicon. The figure of 8.50 Si given by Dr. Wilhemi should be used cautiously, as it is generally admitted that owing to the low temperature carried in the producer, high silicon iron can usually not be obtained.

There is a very wide range of the quality of iron that can be produced, but owing to the necessity to produce an easy-flowing iron, a high percentage of phosphorous will always be desirable.

TABLE No. 3. — ANALYSIS OF IRON PRODUCED

No. of Test	No. of Analyses	C	Mn	P	S	Si
1st	5	1.81	4.69	1.65	.01	8.5
2nd	20	3.02	1.85	1.84	.056	.79
3rd	16	3.69	4.10	1.17	.028	.92
4th	9	3.93	5.95	2.92	.028	.11

TABLE No. 4.—ANALYSIS OF SLAG PRODUCED

Test No.	Fe	Mn	P	SiO_2	Al_2O_3	CaO	MgO	S	$\frac{CaO+MgO}{SiO_2+Al_2O_3}$
1st	1.59	.89	.06	34.8	18.3	39.87	3.05	2.31	.8
2nd	2.39	.81	.18	30.23	16.86	43.26	2.80	3.01	1.0
3rd	2.41	1.73	.14	30.16	16.14	44.31	3.33	2.61	1.0
4th	1.89	5.10	.13	30.96	11.83	38.94	8.42	2.47	1.1

From the above it will be quite evident to the blast furnace operator that a very large range of qualities of iron can be made in the slagging producer by the proper choice of ores and addition of scrap in larger and smaller quantities. In order to assure smooth operation of the producer, it will, however, always be necessary to favor iron high in phosphorous, so as to produce an easy-flowing iron. At the Georgs-Marien Huette in Osnabruck, they are running for a special kind of ferro-phosphorous high in manganese of the following range of compositions:

Mn — 7 — 11% Si — Up to 1%
P — 4.6 — 10% S — Below .05%

They claim that there is a very ready sale for this type of iron at prices away above foundry iron prices among foundries making thin, intricate castings.

With reference to the ferro-phosphorous high in manganese above referred to, I would like to add a few words regarding its marketing ability. This iron which, of course, can be made to answer any desired analysis dependent on the materials used, is in Germany much sought after under the name of Phosphor-spiegel. I have made extensive inquiries in the States in order to find a possible market for it, but so far without avail. Its popularity in Germany is probably due to the fact that both ferro-manganese and ferro-phosphorous were, during the war, extremely scarce and are still hard to get. The phosphor-spiegel was first used in the open hearth to replace the ferro-phosphorous and a part of the ferro-manganese, and it was claimed that its use resulted in a smaller cooling effect on account of a smaller bulk than by using ferro-phosphorous and ferro-manganese. How far this is correct, I have not examined. Later on ad-

ditional users were found in certain foundries making thin and intricate castings who were at least at that time also hard pressed for lack of ferro-phosphorous. The use of this material for both purposes still continues in Germany, and it commands a price of about $10.00 per ton in excess of ordinary 2½ per cent of silicon iron. I would, however, not omit to state that American foundry men have told me that they could see no use for this material on account of its high manganese contents. Be that as it may, the production of this type of iron is not by any means a necessity and will only result where open hearth slag is used as a flux. By substituting suitable ores for open hearth slag, an iron of any desired composition may be made. I personally believe that once the slagging producer has been introduced here, a market for this material will in due course be found, as steel works will naturally want to use their open hearth slag in this manner rather than charge it into the blast furnace. It is of particular advantage that the flexibility of the producer is not affected by the rate of iron production, nor vice versa, the quality of the iron by the rate of operation of the producer.

Utilization of Sensible Heat in Gas.

As will be seen from Table No. 2, from 15 to 17.5 per cent of the heat in the coke goes into the gas as sensible heat. In order to make a slagging producer a paying proposition, it is of the greatest importance that at least part of this heat be recovered. Moreover, it is evident that gas having a temperature of from 1300 to 1400 deg. F. will require special heavily lined mains to convey it. The obvious method to utilize this sensible heat is to turn the gas into the blast furnace gas main and use it in order to increase the sensible heat carried by the blast furnace gas. Where electrical dust precipitation is used, this is an ideal method, as the sensible heat in the gas is not subject to efficiency, but a net gain, in other words, where it is used on boilers, it would as a whole be recovered as steam. In such case, each ton of coke charged in the producer would be responsible for 4,000 lbs. of steam and equivalent to about 400 lbs. of coal, having a fuel value of at least 50 cents. However, in the great majority of cases, blast furnace gas is wet washed and the sensible heat will then become not only a total loss, but an additional burden on the washer. In this case, it will be advisable to install waste heat boilers for the purpose of recovering part of the sensible heat. Assuming the installation of a 200-ton producer—1,170,000 cu. ft. of gas would be produced on an average per hour. The sensible heat contained in this gas is at 1400 deg. F., 26 Btu. per cu. ft. measured cold, or a total of 30,500,000 Btu. If a producer of this kind is equipped with waste heat boilers and economizers, the gas can be cooled down to about 350 deg. F. which corresponds to a boiler efficiency of 75 per cent, so that 22,800,000 Btu. equivalent to 690 bhp. can be recovered in steam. At an evaporation rate of 3¾ lbs. of coal per bhp., this would be equivalent to 1.28 tons of coal per hour, which based on $2.50 coal would have a fuel value of about $3.20 and give a credit of approximately 39 cents per ton of coke charged in the producer.

The waste heat boiler installation would have to consist of 5,500 sq. ft. boiler heating surface and 2,250 sq. ft. economizer surface. For the operation of such a plant, an induced draft fan would be required, which would be operated by a turbine and require 150 hp. Of this amount, 130 hp. would, however, be returned to the feed water by condensing the exhaust steam so that the net power requirement of the waste heat boiler plant would amount to 20 hp.

Another method of utilizing this sensible heat is described by C. H. S. Topholme in vol. 29, No. 23 of Chemical and Metallurgical Engineering. This method is to utilize sensible heat from the producer gas for the purpose of operating a low temperature carbonization plant and in turn, use the semi-coke obtained from this plant as fuel in the producer. Whether this is possible in case of the slagging producer is an open question, on account of the fact that most semi-cokes will carry a large percentage of braize and will not be strong enough to carry the pretty heavy burden of the producer, which owing to the addition of ores and scrap, will be much heavier than in the ordinary coke producer. Should it, however, be found possible to produce a semi-coke suitable for the slagging producer, then the addition of a low temperature carbonization plant would be a logical step in advance, not only for the reason that the gases obtained from the combination of a slagging producer and a low temperature carbonization plant will be considerably cheaper than the cheapest producer gas, but also because the mixture of low temperature carbonization gas and slagging producer gas would give an ideal fuel for open hearth operation, having a heating value of 180 Btu. and being rich in hydrocarbons and therefore yielding a luminous flame.

Slagging Producer as an Equalizer.

As has already been stated before, the chief field for the slagging producer is to serve as an equalizer in blast furnace works in order to equalize the peaks in the gas production and be able to carry a constant load on boilers and gas engines irrespective of the fluctuations in the supply of gas and of temporary shut-downs of the furnaces. It is for this reason that a slagging producer should be chosen large enough to offset two-thirds the total gas production of one furnace and that the 200-ton type will usually be decided upon, which owing to its extreme flexibility, can be operated at rates of as low as 50 tons per day and as high as 600 tons per day.

Financial Side.

The question as to whether or not a slagging producer is a paying proposition will to a large extent depend on the local value of the coke used and whether the gas produced has to compete with auxiliary boiler fuel, such as coal, powdered coal or oil, or with producer gas. The slagging producer will be particularly welcome in districts where there is no ready market for domestic coke all the year round, or where the domestic coke can only be sold at the price of furnace coke or below this price. The extent to which the sensible heat in the gas is utilized and to which extent the production of iron is carried will also have an important bearing on this question. As has already been stated above, both in the interest of smooth operation and of cheapening the gas, the production should be carried to at least 16 per cent of the coke charge.

In order to give an idea of the cost of slagging producer gas, a triple cost sheet is adduced showing the cost of gas without the utilization of sensible heat, with the use of waste heat boilers and the use of electric precipitation for dry cleaning, in which latter case the whole of the sensible heat would be recoverable as steam. For the purpose of this balance sheet, it has been assumed that domestic coke is used containing 85 per cent C in the wet coke at a price of $4.00 per net ton. Wages are figured on the basis of 50 cents per hour for labor and $250.00 per month for each of the three foremen. Power is figured at the rate of 1 cent per kw.

On the basis of 70 per cent producer efficiency referred to cold gas, one ton of the above referred to coke

would produce approximately 150,000 cu. ft. of gas of 115 Btu. For the purpose of producing 16 per cent of iron, the following additions per ton of coke are necessary :

152 lbs. of ore at	$6.00	per ton
564 lbs. of open hearth slag at	.80	" "
105 lbs. of scrap at	14.00	" "

The following Tables Nos. 5 and 6 review the position of the slagging producer, first when it is only used for the purpose of equalizing the gas production, and secondly, when its constant load is for the purpose of replacing a number of coal gas producers and its peak load attends to the equalizing of the blast furnace gas production.

Mr. A. G. Witting in his above quoted discussion of Mr. H. C. Siebert's paper on "Economical Use of Fuel in the Steel Plant," states that for a seven-furnace operation, there are during six hours every day shortages of gas, which in accordance with his calculation require a total of 7,092,000 cu. ft. of additional gas of 90 Btu. to equalize. He advocates using 4,650 gal. of fuel oil at a cost of $232.50 per day to offset this shortage of gas in the boiler house. Table No. 5 has been prepared for the purpose of investigating how the slagging producer would compare to the use of oil in this specific case. As the slagging producer gas contains 115 Btu. as compared to 90 Btu. in the blast furnace gas 5,550,000 cu. ft. of this gas will have to be produced every 24 hours requiring 37 tons of coke.

From Table No. 5, it will be seen that against Mr. Witting's expenditure of $232.50 per day for 5 cent oil, the expense of the slagging producer would amount to $175.60 in the most unfavorable case and $151.10 in the most favorable case.

As Mr. Witting finds that gas shortage only occurs during six hours every day, this method of intermittent operation will naturally result in a comparatively very large expenditure for wages and financial charges. If we want to utilize this producer during 24 hours, it would have to be given a constant load which could best be procured by letting the producer supply the gas for heating furnaces. In compiling Table No. 5, it has been assumed that the constant load of the producer will be to replace the coal gas production from 4-25-ton coal gas producers and that the equalizing of the blast furnace gas producer will be carried as a peak load. For the purpose of putting the coal and coke prices on the proper basis, it has been assumed that the coal used in the producers would only cost $2.75, so that the comparison is on the basis of coke at a price of 45 per cent higher than coal and would show that in this case any kind of coke could be used to the full value of blast furnace coke. Basing the coal producer operation on a coal price of $2.75 per net ton and on a conversion cost including steam, labor, repairs, upkeep and financial charges of $2.00 per ton, which must be considered very excellent practice, the total amount of money spent per day on these four producers would amount to $475.00. Adding to this the $232.50 for oil, the total expense to which the operation of the slagging producer would have to be compared amounts to $707.50 per day. Assuming that the coal producer would operate on a 75 per cent efficiency, the heat in the producer gas from 100 tons of coal would amount to 1,950,000,000 Btu. To produce this amount of heat from a slagging producer, it would require 113 tons of coke per day. Adding to this the 37 tons of coke which are required for equalizing purposes, the producer would have to deal with 150 tons of coke per day. This would require a larger type of producer, the cost of which including material-handling and blowing equipment, would be in the neighborhood of $125,000.00.

A slagging producer in this case would therefore produce profits ranging from $280.00 to $365.00 per day, as compared to auxiliary oil firing and four gas producers for heating furnaces. In addition thereto, the very important advantages derived from automatic equalizing have to be taken into account, which although difficult to express in dollars and cents, will nevertheless readily be appreciated by the blast furnace operator.

As is shown by Table No. 6, the value of 1,000,000 Btu. from $4.00 coke varies from 12.8 cents to 15.9 cents. The corresponding figure for coal producer gas from $2.75 coal, plus $2.00 per ton conversion charge at 75 per cent efficiency will be 24.4 cents or 53 to 90 per cent more than that of the slagging producer gas. In order to get a comparison between the respective cost of 1,000,000 Btu. latent heat derived from coal gas and slagging producer gas, Table No. 7 is adduced. The heat value

TABLE No. 5.

Debit	Debit	Credit (a) Without utilizing sensible heat.	Credit (b) Using waste heat boilers.	Credit (c) Using electric precipitation.
37 tons of coke at $4.00	$148.00			
2.82 tons of ore at $6.00	16.90			
10.4 tons of open hearth slag at 80c	11.20			
1.92 tons of iron scrap at $14.00	27.00			
Power approximately 1400 kwh.	14.00			
Wages 6 men and 3 foremen	49.00			
Cooling water 80,000 gallons	.60			
Repairs, etc.	19.90			
Financial charges 15% of $75,000	31.00			
	$317.60			
Credit				
5.9 tons of iron at $24.00		$142.00	$142.00	$142.00
Steam at 16c per 1,000 lbs. at 60 per cent efficiency in waste heat boilers 88,000 lbs. of steam		.....	14.10	.....
Steam from sensible heat 147,000 lbs. of steam		.....	.....	23.50
Total credit		$142.00	$156.10	$165.50
Actual cost of 5,550,000 cu. ft. of gas at 115 Btu.		175.60	161.50	151.10
Cost of 1,000,000 Btu.		27.5c	25.2c	23.6c

of the wet coke is assumed at 24,800,000 Btu. of the coal at 26,000,000 Btu. per net ton.

This table shows that if the sensible heat is not utilized $7.00 coke in the slagging producer will about cut even with $4.85 coal in the coal gas producer, if the sensible heat is utilized. $8.00 coke will about cut even with $5.50 coal.

As has already been stated elsewhere, slagging producer gas is eminently suitable for soaking pits and all kinds of heating furnaces, while it is an open question whether it can be utilized in open hearth furnaces. But, there cannot be any doubt, that coke oven gas mixed with slagging producer gas, say in the relation of 1:1, will give an ideal open hearth fuel, this mixture having a high heating value of 300 to 310 Btu. and 16 to 18 per cent CO, which latter is always welcome.

TABLE No. 6.

Debit	Debit	Credit (a) Without utilizing sensible heat.	Credit (b) Using waste heat boilers.	Credit (c) Using electric precipitation.
150 tons of coke at $4.00	$600.00			
114 tons of ore at $6.00	68.40			
52.5 tons open hearth slag at 80c	42.00			
7.8 tons of scrap at $14.00	108.50			
Power approximately 5400 kwh	54.00			
Wages 9 men and 3 foremen	61.00			
Cooling water 310,000 gallons	2.40			
Repairs, etc.	25.00			
Financial charges: 15 per cent of $125,000	52.00			
	$1,013.30			
Credit				
24 tons of pig iron at $24.00		$586.00	$586.00	$586.00
Steam at 60 per cent efficiency from waste heat boilers 364,000 lbs.		.....	57.00	.....
Steam from sensible heat, 595,000 lbs.		.....	.....	95.30
Total credit		$586.00	$645.00	$681.30
Actual cost of slagging producer gas 22,500,000 cu. ft. of 115 Btu.		427.30	370.00	342.00
Cost of 1,000,000 Btu.		15.9c	13.7c	12.8c

TABLE No. 7.

Slagging Producer		Coal Gas Producer	
Price of Coke	Cost of 1,000,000 Btu. in gas.	Price of Coal	Cost of 1,000,000 Btu. in gas.
$4.00	12.8 — 15.9c	$2.75	24.4c
$5.00	18.9 — 22.2c	$3.45	28.0c
$6.00	24.7 — 28.0c	$4.15	31.5c
$7.00	30.2c— 33.8c	$4.85	35.1c
$8.00	35.6 — 39.5c	$5.50	37.4c

Eliminating Coal from Steel Works.

This brings us back to the introduction of this paper where the desirability of having coal enter at the coke oven plant only was emphasized. The ideal method of fuel handling in the steel plant would be to install at the coke ovens a slagging producer plant of sufficient size.

First—To fire the coke ovens.

Second—To mix with the coke oven gas in any desired relation to produce satisfactory open hearth fuel.

Third—The balance to be sent into the blast furnace gas main.

(a) To equalize blast furnace gas production.

(b) Mixed with blast furnace gas to supply deficiency of mixture of coke oven and slagging producer gas for all kinds of furnaces other than open hearth furnaces.

I believe that I have about demonstrated that this ideal is brought by the slagging producer very near to realization. The desirability of heating coke ovens by producer gas is gaining more adherents every day. That slagging producer gas is suitable for this purpose is proven by the fact that in Europe very frequently very much poorer blast furnace gas is utilized for this purpose. Tables 5 and 6, particularly the latter, show conclusively that the slagging producer for the replacement of auxiliary fuel and of coal producer gas by slagging producer gas is an excellent paying proposition. Particularly in new plants where producer gas-fired coke ovens are erected and coal gas producer dispensed with in favor of the slagging type, this producer will not only mean a very considerable reduction in first cost, but also a great relief in the labor situation, as not only all coal handling except at the ovens is dispensed with, but also because fewer and less skilled laborers are required for the operation of the slagging producer.

Conclusion.

The slagging producer is no longer an experiment, but a fully proven commodity. Its range of fuels is still limited, the best fuel still being domestic or blast furnace coke. The operation is very similar to the ordinary blast furnace, requiring, however, very much less attention and skill. Iron production is a necessity, and for economical reasons should be pushed as far as possible. The cost of slagging producer gas compares favorably to oil firing. Its cost is considerably lower than that of coal producer gas.

I wish to acknowledge with thanks the assistance given to me in the preparation of this paper by Mr. von Holt, Dr. Wilhemi and Dr. Bansen, who can very well be considered pioneers in the recent development of slagging producers.

Crane Hoist Travel Limit Devices

By WALTER GREENWOOD*

FAILURE of regulating devices for control of electrical apparatus is the chief cause for mishaps that cause impairment of electrical equipment and machinery operated by electrical equipment. Also, it is the cause for delay of operation, loss of production and injuries to persons while engaged in handling electrically operated equipment. The list of devices that fail and produce disastrous results include automatic breakers of various kinds, switches, speed limits and travel limits.

The chief purpose of this paper is to get our Association to approve such general standards covering the important feature for construction and installation of hoist limit devices for limiting travel of hoists on overhead electric cranes or any type of electrically operated hoist, as will in the highest possible degree prevent accidents due to the failure of a device to properly function.

The failure of hoist limit devices is of such frequent occurrence we are not surprised at the attitude of some whose preference is to rely entirely on operators to stop the hoist travel at the proper time instead of employing a limit device that is not entirely dependable. They reason an operator knows the consequence of neglect, and since he is held responsible and must suffer for his failure his mind and body become accustomed to act with automatic precision. All this may be nearly true as regards operators having long experience, especially on one crane or in a particular line of work, but what about the new beginners or operators whose experience has been limited to the work done under the guidance of a trainer? It takes long practice for anyone to become so familiar with the various movements of his machine, some two or more of which movements frequently are simultaneous, that with seeming instinct his acts are correctly performed. There is no available data to show the relative frequency of mishaps that occur through neglect of operators to stop hoists where no limit devices have been installed, and mishaps that occur through failure of limit devices to properly function.

It is a general belief that limit devices where installed have very nearly made impossible mishaps that can occur from neglect of operators to apply the control equipment. It is known that limit devices, claimed by their makers to be faultless and infallible, do fail. In answer to the question, "Are they entirely dependable?" the common reply is, "No." Replies made by some superintendents, where a large number of cranes are included under their management, is, failure of some one of the total number of limits employed does occur as often as once each week. Such a statement seems to be extravagant. These failures frequently are expensive; sometimes the expense is increased by delay of operations, loss of production, and, too, loss of life from such mishaps is not an uncommon occurrence. In one mill that we know of, two separate fatalities occurred within one month, notwithstanding the rule is, a limit stop on a hoist is not to be brought into service unnecessarily or that it is not to be used as a utility, yet the fact is this rule is not always obeyed. Confidence of the operator in the reliability of the device to perform its office at all times may lead him to depend on it despite the fact that he is violating a rule.

In discussing hoist limits with various persons, these points have been agreed on: A hoist limit device should be considered as only an auxiliary to manual control. The principal features of limits are interruption of current and the application of dynamic braking, and the addition of any other feature involves care and attention that means additional maintenance cost. If they do not automatically reset, the time consumed in resetting, if the method is purposely made inconvenient, will sometimes be a serious delay, and it encourages operators to make the limit inoperative. If proper attention is not given to the method of installation and to maintenance their reliability is much affected.

Almost any part of electrical equipment is liable to fail when it is not expected to or suspected of being out of condition. While claims are made for the ruggedness of each producers' wares when enumerating their qualities, the term rugged applies only in a relative sense, for delicacy is an essential quality to some parts of electrical equipment. Where unfailing accuracy of operation of a piece of equipment must be demanded, and where failure is a possibility of said equipment—it being a safeguarding device—is made a utility, it is only a question of time when a failure must occur, then damage or an accident is most sure to follow. The only way that seems possible for preventing operators from making a hoist limit device a utility is to provide a tell-tale device that will reveal when and by whom it is brought into service. This will enable the authorities in charge to determine whether or not the failure to avoid its unnecesary operation is excusable. There is not much likelihood that an operator will, knowingly, neglect a requirement where a penalty is provided for so doing. The only argument that can be offered against installing a tell-tale device is added first cost and cost of maintenance. The justification for this is a matter for the authors of a code for government of construction and installation of hoist limit devices to consider.

It has been suggested that operators will be less inclined to make a utility of an automatic limit if the resetting of it is made extremely difficult. An operator that would purposely make a utility of a limit is a person whose conscience would not be troubled if he made the limit inoperative. Naturally he would be inclined to do this and depend on his ability to avoid too much travel of the hoist. The method has been tried where the result was not satisfactory, one of the objections being delay of operations at periods when delays were expensive.

In too many cases the installation of a protective device is made by persons who in some particulars disregard instructions furnished by the maker of the device. This is done in some cases because the requirements are thought to be unnecessary and cost can be reduced; in other cases because they think they can see better methods, and too, in some cases perhaps they do see them. This is added proof that standard general principles should be decided on.

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Machine Tools and Their Auxiliaries in the Steel Mills

By J. F. KELLY*

THE steel industry today is as strong or as weak as its maintenance departments, and, argue as you will, its success or failure in any plant is largely due to the manner in which its maintenance departments are organized and equipped. What matters it if your plant can boast of the most modern installations unless you have provided the necessary tools for its upkeep? In a very short time your plant will be subject to annoying costly delays, which interfere with your production schedules, and consequently you are not making profits—but producing at a loss.

You say these are self-evident facts, but in making up budgets for your board of directors, how often is it the case when the estimates are pruned, that the maintenance departments receive the least consideration, and sometimes no consideration at all? There have been instances in the history of the steel industry where fabulous sums were expended for buildings, mill equipment, power houses; and yet practically no money set aside, worth mentioning, for maintenance departments, with the result that these modern plants were continually being delayed by first minor breakdowns—then major ones; production was seriously handicapped, all due to the fact that no provisions had been made for maintenance. Here are glaring examples of too much mill—too little shop.

Maintenance, the steel industry will always have with it, and this fact must be fully recognized by the managements, if they desire their production schedules maintained. Maintenance departments are responsible for the continuity of operation, for the development of apparatus which will produce the large tonnages desired, yet too often is this most salient fact overlooked.

Accepting this as a basis for argument, why is it that so little effort and so little importance are attached to seeing that these departments are equipped with all of the modern improvements, calculated to preserve the continuity of operation?

On every hand we hear, first, "Increase your production;" second "Lower your costs;" third, "Reduce your stores supply." The answer to this it would seem is:

Organize your maintenance departments and equip them with the same careful analysis you devote to your production problems; if your mills are always prepared to operate, it naturally follows your production will not suffer.

How would the steel industry receive the suggestion that the superintendent of maintenance rank with the superintendent of production? It would be presumptuous for the writer to insist that the electrical engineer should accept this responsibility, yet in the past he has displayed an ability to solve the fast changing problems arising from the application of electricity in the manufacture of iron and steel, and since plants today are being completely electrified, he will no doubt fall heir to this.

It is not the purpose of this paper to try to cover maintenance in general in the steel industry, but to devote ourselves to that department known as the machine shops, or the machine tool departments.

Thomas R. Shaw, London, England, definition for machine tool is as follows: "The true function of such a machine is the production of a machine part, and stated simply, a machine tool is a machine having a combination of mechanisms, whereby a cutting tool is enabled to operate upon a piece of material to produce the desired shape, size and degree of finish—such work being effected by the actual removal or cutting away of the surplus materials.

A machine tool is a combination of iron and steel mechanism whose driving energy is in exact relation to its metallurgical structure and the cutting tool which operates upon the material to produce the desired shape, size and degree of finish is of such physical structure which has some predetermined relation to the energy driving the machine tool, and the iron and steel mechanisms which make up the major parts of the machine tool."

However, this definition, to our minds, should be amplified and changed to read as follows:

"A machine tool is a combination of iron and steel mechanism whose driving enregy is in exact relation to its metallurgical structure."

It is the humble opinion of the writer that, highly specialized as the machine tool industry appears to be, yet there is not the complete service in evidence which this wonderful industry could and should boast of. This industry should be prepared to offer in connection with its various services the following additional information and data, which would go a long way to correct the impression that maintenance shops are simply a necessary evil. They should be prepared to offer to any industry a consulting service which would cover maintenance shops, beginning with the buildings, the complete tooling of the departments, systems for operating departments. The use of this service would immediately dispel the idea that maintenance shops were simply after-thoughts. It would also raise the dignity of the machine tool industry to the rank which it should hold.

BUILDINGS

The locations of maintenance departments as a rule are never seriously considered. Often they are simply crowded into what is left over after the building program is completed; very often they are placed in lean-tos; often in the extreme ends of the plant; very rarely are they centrally located. No thought is given as to how material will be transported to and from the shop; how much railroading is necessary for transportation; also how close the raw material stocks are located to the shops. Certainly an effort should be made to see that all maintenance departments are located to require the least amount of material handling.

Structures.

Buildings should be of a brick structure—air insulated from all other buildings, and foundations to prevent vibrations and shocks from mill machinery cracking and tearing the building. The roof should be of

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good material to prevent leaking. Liberal allowances should be made for as much artificial lighting and wired glass should only be used in skylights. Make your shop large enough in your first estimate to allow for plenty of room for machine tools, and also for future expansion. Endeavor if at all possible to have your floors made up of concrete and cement. Avoid the use of brick on account of spawling. Wood floors are not satisfactory.

Lighting.

There is no question but that modern lighting will enable the worker to turn out more work each day; also that there is more satisfaction in working in a shop that is well lighted than in one which is dirty and poorly lighted. Poorly illuminated shops are usually those which, according to very careful investigations, produce the highest percentage of industrial accidents.

Modern lighting reduces spoilage, improves sanitation, and also helps to conserve the operators' eyes. Also more work and better work by the operator.

Localized lighting was the first method used for shop lighting, however, this has been gradually superceded by general illumination, which does away with chiefly glaring conditions, which is admitted to be hard on the eyes. Breakage is also eliminated, however localized lighting has some advantage in extremely fine work on internal boring.

There are a few processes, including deep boring, punching and pressing of large blanks, lathe work on minute parts, such as watch mechanisms and the like, which require local lamps. With these few exceptions, machine tool work can be carried on most effectively with the artificial lighting taking the form of overhead units. This statement is borne out by numerous satisfactory installations in constant use. Many mechanics will argue otherwise, thinking they cannot work unless there is a drop lamp directly over the tool, but this is largely a question of psychology. After a new system has replaced the old, everyone is usually enthusiastic in his praises, after becoming accustomed to the change. The system to use for lighting machine tools depends on the type of building.

There are many degrees of precision requiring different amount of light and the Mazda lamp with its wide range of sizes enables these conditions to be met easily. The following table indicates a good practice for general lighting of machine tool works:

Rough work, 4 to 6 foot-candles; 0.6 to 0.75 watts per square foot.

Average Work, 6 to 8 ft.-candle; 1.0 to 1.25 watts per square foot.

Fine Work, 8 to 12-ft.-candle; 1.5 to 2.0 watts per square foot.

A safe general rule for a satisfactory installation in a machine shop of this nature is that the spacing should be about equal to the distance above the floor, thus in a room where units would be mounted 20 feet, one per twenty-foot bay would be satisfactory. If 40 feet high, one unit every two bays, while with the 10 foot mounting height, 4 units per bay would be desirable.

Where the ceiling is low, in order that the predominant light may come from a proper direction, it is most generally advisable to use localized general lighting, which is an intermediate practice between general and local lighting, with common sense used in the placement of outlets. In Diagram A is shown the difference in arrangement between a general and a localized general lighting layout. In the case of the symmetrical arrangement, an analysis shows that many of the units are quite ineffective. For example, two are located directly behind the shapers, in which position they would be of little use. The lighting of the lathes along the wall would be from the wrong direction; the headstock would cast

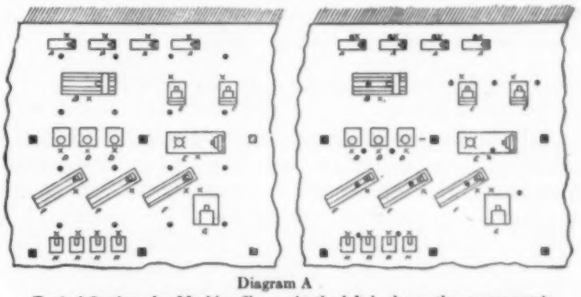

Diagram A

Typical Section of a Machine Shop. At the left is shown the arrangement of outlets for symmetrical general illumination; at the right is shown arrangement of outlets for localized general lighting. A—Lathe (engine). B—Large Planer. C—Shaper. D—Drill Press. E—Lathe (turret). F—Automatic Screw Machine. G—Universal Miller. H—Emery Wheel and Buffer. O—Lighting Outlet. X—Position of Operator

a shadow on the work. A similar analysis might be carried out for the entire hypothetical arrangement. In the other half of the diagram, the lighting units are arranged so that the correct direction of light results, the position of each machine being taken into consideration.

One might justly bring up the criticism that this is nothing but an extravagant system of local lighting providing a rather large lamp for each machine. On the other hand, one would be willing to grant that, with our present standards, the use of four 100 or 150-watt lamps in a 20-foot bay was not extravagant for general lighting. If the number of units in the four bays pictured is tallied, the general lighting system would show 16 and the localized general 17. An analysis similar to this of entire shops has been made time and time again, and the power reqnired for a localized general system checks np very closely with the power required for a general lighting system.

With such arrangement, each machine receives the kind of lighting it requires. All the advantages of general lighting are obtained and the disadvantages of local lighting eliminated.

Space will not permit a more detailed discussion of this question which is of great importance, and it is hoped that the example given will indicate the method of attacking a lighting problem of this nature. One should not attempt to place the outlets for a machine shop with a relatively low ceiling without taking into consideration the location of the individual machines.

Heat.

To heat a machine shop properly has always been more or less of a problem. Most shops are heated enough, but the systems used are costly and require a great deal of attention. It would appear that electrical heat should solve this vexing problem, in as much as it is much more flexible and may be regulated to a closer degree than the present systems.

Sanitation.

Many of the steel companies have spent thonsands of dollars to properly fit up wash-rooms and lavatories for the conveniences are appreciated by the men, as the atmosphere created by the idea of cleanliness, eventually spreads all over the shop with the result that men

are much more content and willing to work in clean shops, rather than those which are dirty. Machine operators are more inclined to keep their machine cleaner, and laborers more inclined to keep the floor clean and the aisles clear, where the environment is for cleaner and better shops.

Every shop should be equipped with lockers, washrooms, and by all means the best and most sanitary lavatories. Janitor service should be supplied for those rooms, and they should be kept clean.

Crane and Material Handling in Steel Mill Machine Shops.

The importance of speed and efficiency in production in steel mills is such that there must be a liberal capital expenditure in reliable crane equipment. All machine tools handling material too heavy to be readily lifted by one man, should be located so that they can be served by a crane of sufficient capacity to handle the heaviest pieces that the tool can take. Accurancy of control of the various motions of the crane, is essential so that work can be accurately located or placed in lathe centers and to prevent damage to expensive machinery by losing control of a piece of heavy material.

Where machine shops are handling a continuous flow of material of a uniform character, gravity or power conveyors may be used for a horizontal transfer, but where the flow is not uniform, power trucks perhaps equipped with lift platforms to raise the work to the machine, can be used to better advantage. In this respect each shop is a problem in itself, and must be studied to see what type of material handling machinery can be used to best advantage, bearing in mind that at present wages the saving of a few laborers or 25 per cent of the time of a few machinists, will pay the interest, depreciation and maintenance on a considerable amount of capital in labor saving machinery.

Storage.

Too often are the machine shop aisles and floors littered up with forgings and finished apparatus, so much so, that it is almost impossible to move around without a "near accident". Why this condition in a maintenance shop is allowed to exist is beyond comprehension.

Every shop should have its storage yard at one end of the shop for its raw stocks, and a storage yard at the other end for its finished stock. The aisles should be kept perfectly clear and the floors clean. Properly kept storage yards will often save many hours' expensive labor, hunting for the material required.

SELECTION OF MACHINE TOOLS

It naturally follows in the selection of machine tools that the apparatus you must repair or keep in operation is a factor determining what type of tool you will have to install and experience and common sense will play a prominent part in your selection.

Lathes and Drilling Machines.

Lathes and drilling machines rank high among the basic machines of all maintenance shops. Some of the most important features to be considered in their selection are;

First—Control.

Control. is the essence of machine tool operation Keep in mind that the machine should do the work. That the operator should use his energies only in directing the machine. This is made possible through the use of centralized control, which eliminates wasteful movements, makes possible easier working conditions, not so many tedious manipulations.

Second—Structure.

Make sure your machines are heavy enough and are metallurgically constructed from metal which will stand up under abuse, bearing in mind also that your machine tools will be subject to unusal strains and shocks. In this particular I wish to call attention to perhaps a minor feature which is often overlooked, and that is that the human element has a great deal to do with the operaton of the machine. Every time you change operators on a machine it is usually necessary for him to find out by experience the characteristic of the machine, and in gaining this experience, often subjects the machine to heavy overloads and shocks. Eliminate cast iron gears wherever possible. Use high grade steel. Do not allow price to influence your decision, in selecting machine tools.

Third—General.

To reduce production cost is the aim of every machine shop foreman, and he is often tempted to force a machine beyond its capacity by the use of a high grade tool steel. It seems to be the concensus of opinion that the machine tool builder has not kept pace with the tool steel builder, with the consequences that machine tools are being continuously serviced with spare parts.

Make sure that the machine that you are about to purchase will take care of the advancements in the art of high grade tool making.

It does not necessarily apply that the use of the highest grade of tool steel in all shops is good shop practice, since all machines are not so equipped to take care of the unusual strains, nor are they capable of absorbing the heavy overloads imposed by the use of high grade cutting steel.

Motor Driving.

The driving of machine tools direct by motors has many advantages on the larger sizes of machine tools, but the advantages have been accomplished by difficulties owning to the varying types of motors, voltages, etc. The all-gear drive, however, has rendered the adaptation of the motor to the machine tool a simple matter, as it enables a constant speed motor to be used which may be of any voltage, either direct or alternating. The utility of the variable speed motor is, of course, not in question, and it frequently enables the mechanism of the machine to be simplified.

The advantage of motor-driving, viz; freedom from overhead gear and belting; the possiblity of placing the machine in any position in the workshop; the possibility of having cranes passing directly over the machine; and where motor driven machine tools alone are employed, the possibility of having a cheaper workshop construction, will doubtless lead to its extended use in the future.

The use of electric drive with magnetic control has many advantages, among which may be mentioned:

1—The use of automatic features, such as overload protection, automatic acceleration, and interlocking on machines with more than one motor, is more easily accomplished by electrical aquipment than by mechanical devices.

2—The maintenance of the equipment is reduced by the ability to provide overload protection, to eliminate excessive strains and by the elimination of maintenance on belts, clutches and shafting.

3—The elimination of overhead belts and shafting permits better lighting due to absence of shadows, and gives more room for the operation of cranes.

4—A more suitable arrangement of machines with respect to production is possible; the location not being in any way determined by the position of shafting.

5—Production is increased due to greater convenience to the operator.

6—The safety of both operator and machine is increased.

7—Power consumption is decreased, due to the saving of friction in line shafting and belt slip.

8—Portable machines are possible.

The use of electric drive with magnetic control may result in an increased first cost for the installation. In an old installation, the cost of change-over is the equivalent of an additional investment, and the results obtained must be sufficient to justify it. In a new installation, however, the saving of shafting, pulleys and belting may be nearly as much or sometimes more than the cost of the, electrical equipment. The increased safety, convenience and production offset the increased investment where normal operating conditions obtain.

Now that we have our buildings erected and all properly finished, the question arises "How shall we tool our shop?" In our proceedings at least, and I do not fancy that the knowledge is general, is there any data which answers this particular question? I realize the tremendous amount of information which would have to be compiled to cover all industry in this respect and perhaps that answers the question.

However, before we select our machine tools, it might not be out of order at this time to state something in connection with the earlier history of machine tools.

HISTORICAL

Fundamental principles. The lathe, the most generally used of all machine tools, is indispensable for the execution of all kinds of circular work in wood and metal. In its most ancient form, it was probably the potters' wheel, from which it advanced, by successive improvements, to its present highly improved form.

It is from this machine that the two great fundamental principles arose which govern all machine tool design. First by whatever means a substance capable of being cut could be made to revolve with a circular motion round a fixed right line as a center, a cutting tool applied to its surface, would remove the inequalities, so that any part of such surface should be equidistant from that center; and secondly, the slide rest of Henry Maudslay, by which a cutting tool could be firmly fixed, and constrained to slide along a surface in a direction exactly parallel with the axes of the work.

In turning a piece of work on the old-fashioned lathe, the workman applied and guided the cutting tool by means of muscular strength. The work was made to revolve, and the turner, holding the cutting tool firmly upon the long, straight, guiding edge of the rest, along which he carried it, and pressing its point firmly against the article to be turned, was thus enabled to reduce its surface to the required size and shape. Some dexterous turners were able, with practice and carefulness, to execute very clever pieces of work by this simple means; but when the article to be turned was of considerable size, and especially when it was of metal, the expenditure of muscular strength was so great that the workmen soon became exhausted.

The slightest variation in the pressure of the tool led to an irregularity of surface, and with the utmost care on the workman's part, he could not avoid occasionally cutting a little too deep, in consequence of which he must necessarily go over the surface again, to reduce the whole to one level, and thus probably the job would be altogether spoiled by the diameter of the article under operation being made too small for its intended purpose. The introduction of the slide rest furnished a complete remedy for this source of imperfection.

Invention of the Slide Rest

Maudslay, seeking for the best methods of ensuring accuracy, and also to be independent of the carelessness or want of dexterity of the workman, aimed at the

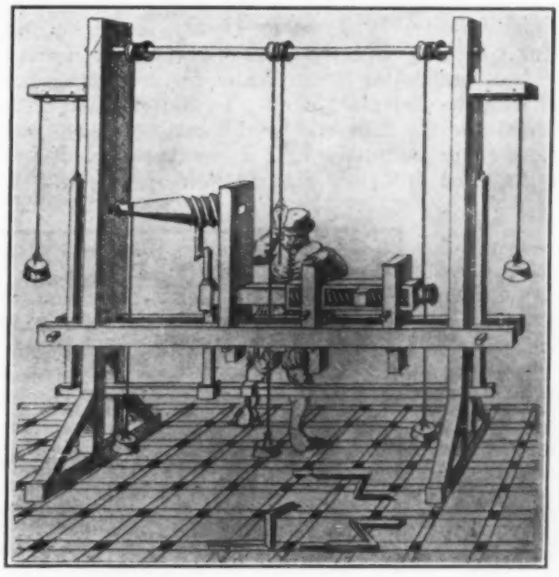

FIG. 1—*A screw-cutting lathe of the sixteenth century.*

contrivance of machine tools, which should be as self-acting as possible, and it was while pursuing this study that he made the important invention with which his name is usually identified—that of the slide rest. The cutting tool, till then held in the uncertain grasp of a workman, was held in a hand of iron and guided in mathematically straight lines, thus making accurancy possible.

All that the workman had to do, after the tool was firmly fitted in the rest, was merely to turn a crank handle, and thus advance the tool along the face of the work as required, with an expenditure of strength so slight as scarcely to be appreciable. And even this labor has been gotten rid of, for, by an arrangement of gearing, the slide itself has been made self-acting, and advances with the revolution of the work in the lathe.

Importance of the Slide Rest

It is not, indeed, saying at all too much to state, says Mr. Nasmyth, a most competent judge in such a matter "that its influence in improving and extending the use of machinery, has been as great as that produced by the improvement of the steam engine, in respect to perfecting manufacturers and extending commerce, inasmuch as without the aid of the vast accession to our power of producing perfect mechanism which it at once supplied, we could never have worked out into practical and profitable form, the conceptions of those master minds who have so successfully pioneered the way for mankind. The steam engine itself, which supplies us with such

unbounded power, owes its presence to this most admirable means, giving to metallic objects the more precise and perfect geometrical forms.

How could we, for instance, have good steam engines, if we had not the means of boring out a true cylinder, for turning a true piston rod, or planing a valve face. It is this alone which has furnished us with the means of carrying into practice the accumulated results of scientific investigation on mechanical subjects." It would be blameable, indeed, contines Mr. Nasmyth, after having endeavored to set forth the best advantages which have been conferred on the mechanical world, and therefore on mankind generally, by the invention and introduction of the slide rest, where I to suppress the name of that admirable individual to whom we are indebted for this powerful agent towards the attainment of mechanical perfection. I allude to Henry Maudslay, whose useful life was enthusiastically devoted to the grand object of improving our means of producing perfect workmenship and machinery. To him we are certainly indebted for the slide rest, and consequently, to say the least, we are indirectly so for the vast benefits which have resulted from the introduction of so powerful an agent in perfecting our machinery and mechanism generally. The indefatigable care which he took in calculating and effusing among his workmen and mechanical men generally the sound ideas of practical knowledge and refined view of construction, have rendered and ever will continue to render, his name identified with all that is noble in the ambition of a lover of mechanical perfection.

The Early Machine Tool Makers.

It will not be out of place here to refer very briefly to the influence of the early tool builders. There connection is shown in the genealogical table (Fig. 2). Bramah, one of the earliest engineers, who we might say had an influence on the development of machine tools, had a workshop in London, where for many years he manufactured locks and built hydraulic machinery and woodworking tools. From association with him came the long line of men, famous in machine tool history.

Maudslay, who is probably the finest mechanician of his day went to work for Bramah when he was 18 years old, and became his foreman in less than one year. He left after a few years because he was getting only

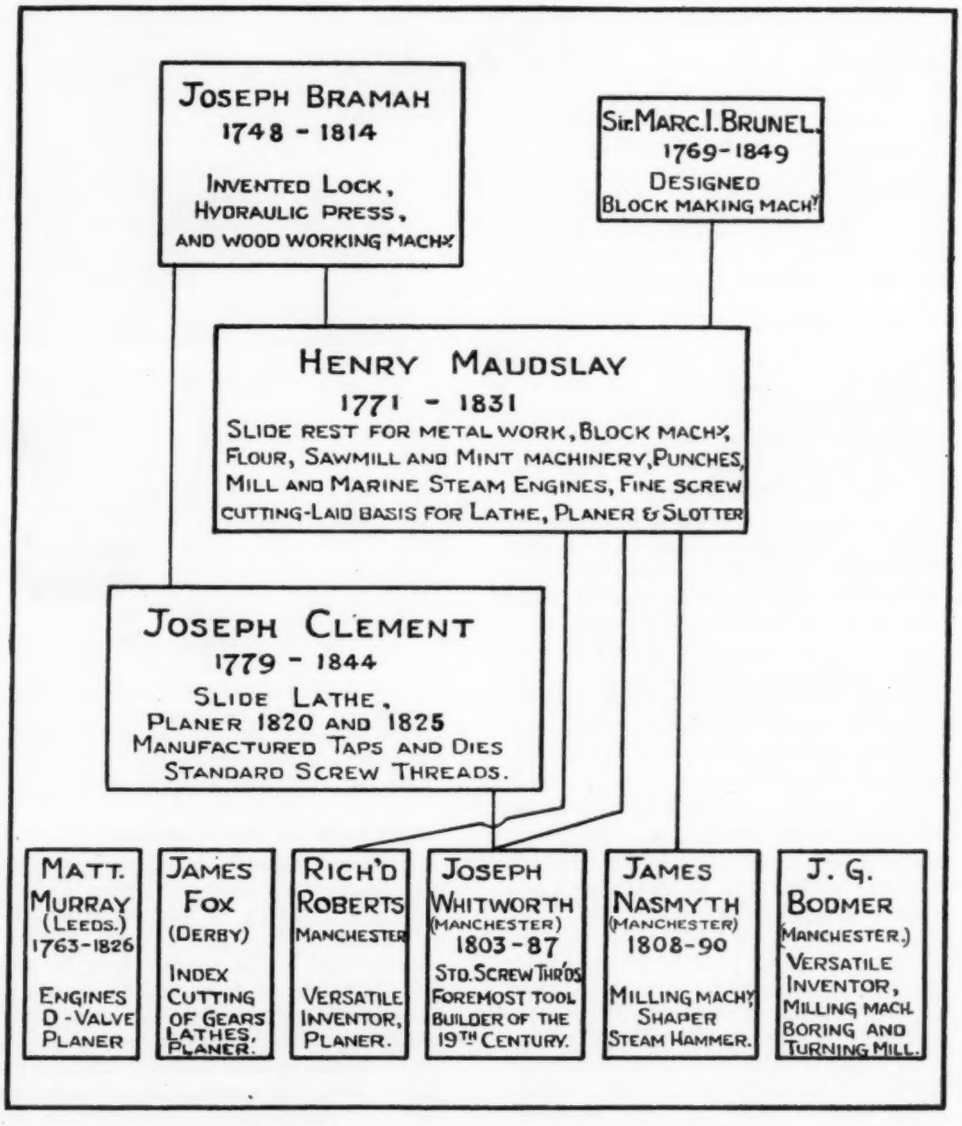
JOSEPH BRAMAH
1748 - 1814
INVENTED LOCK, HYDRAULIC PRESS, AND WOOD WORKING MACHY
SIR MARC I. BRUNEL
1769-1849
DESIGNED BLOCK MAKING MACHY
HENRY MAUDSLAY
1771 - 1831
SLIDE REST FOR METAL WORK, BLOCK MACHY, FLOUR, SAWMILL AND MINT MACHINERY, PUNCHES, MILL AND MARINE STEAM ENGINES, FINE SCREW CUTTING-LAID BASIS FOR LATHE, PLANER & SLOTTER
JOSEPH CLEMENT
1779 - 1844
SLIDE LATHE, PLANER 1820 AND 1825 MANUFACTURED TAPS AND DIES STANDARD SCREW THREADS.
MATT. MURRAY (LEEDS.) 1763-1826
ENGINES D-VALVE PLANER
JAMES FOX (DERBY)
INDEX CUTTING OF GEARS LATHES, PLANER.
RICH'D ROBERTS MANCHESTER
VERSATILE INVENTOR, PLANER.
JOSEPH WHITWORTH (MANCHESTER) 1803-87
STD. SCREW THR'DS FOREMOST TOOL BUILDER OF THE 19TH CENTURY.
JAMES NASMYTH (MANCHESTER) 1808-90
MILLING MACHY SHAPER STEAM HAMMER.
J. G. BODMER MANCHESTER.)
VERSATILE INVENTOR, MILLING MACH. BORING AND TURNING MILL.

FIG. 2—*Genealogical table of early tool machine makers.*

30 shillings a week, and started in business for himself.

Brunel was a young French officer, who had been driven out of France by the Revolution. He was a clever designer. He designed a set of block making machinery for the Portsmouth dock yard and requiring someone to make his machinery was referred to Henry Maudslay.

the open side planing machine, grinding machine, and gear cutting machine.

Many of Bodmer's schemes have been reinvented and patented years afterwards. Bodmer's machine (Fig. 3) is practically the machine of today, including a circular V path for the table, a means for raising the

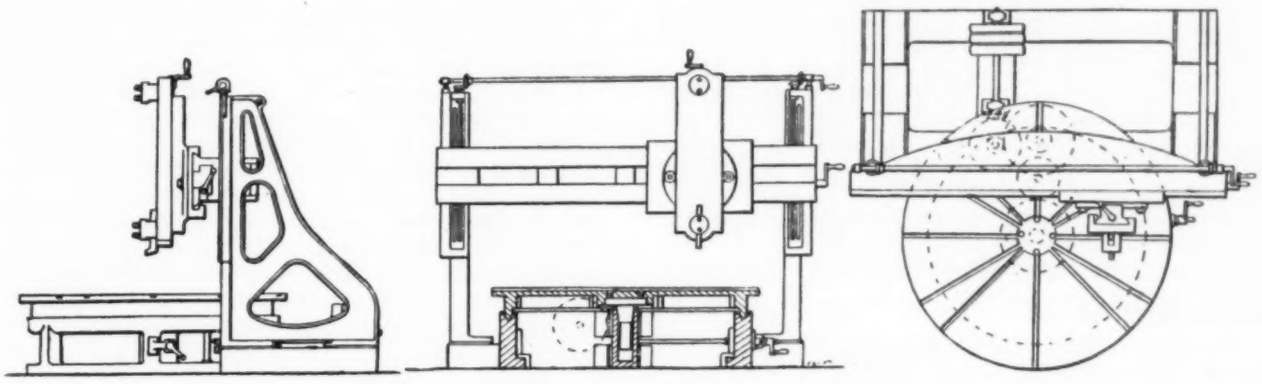

FIG. 3—*Bodmer's boring and turning mill.*

Maudslay built the machines and they were brilliant success. Of the early tool builders, Maudslay was undoubtedly the greatest. As above mentioned, he developed the slide rest, and thereby laid the basis for the design of all other machine tools.

Joseph Whitworth went to London and worked for Bramah as chief draftsman and superintendent of his works . After Bramah's death he went to Maudslay's, and later went in business for himself.

He was a clever inventor and played a very important part in the development of the planing machine and the screw cutting lathe.

Joseph Whitworth, the greatest tool builder of the nineteenth century, worked for Maudslay and for Clement, and took up this work at the point where they left off. He standardized the screw threads over all England, and brought order out of chaos. Under his influence machine tools were given a strength and precision which they had not known before.

Richard Roberts of Manchester, England was another pupil of Maudslay's, whose influence though important was not so great as that of the other.

James Nasmyth also of Manchester was possessed of rare mechanical skill, and as a young man his one ambition was to go to London to work for Maudslay. With his name is associated principally the development of the steam hammer and the shaping machine. His respect for Maudslay is seen in his eulogy of the slide rest.

A contemporary was Matthew Murray of Leeds, who is credited by some with the invention of the planing machine, which honor is also claimed by James Fox of Derby.

There is another whose name is not so familiar, but who was one of the finest engineers of the time. He was John George Bodmer. He had a workshop in Manchester, but owning to his energies being devoted more to inventing and experimenting than to profit making, his business became a failure and he was eventually closed up. A patent issued to Bodmer in 1839 was very large and comprehensive, and showed that he thoroughly understood the subject of machine tools, and had many advanced ideas regarding their construction. Included in his patents are: the boring and turning mill, spindle and table off the bearings, in order to rotate it at high speed. It may be said about this invention of Bodmer's, that it was not only novel and new at the time of his constructing it, but that it has only been improved upon since in some of its details. Bodmer was really many years in advance of his time, the result being that no one had confidence in him, and he was looked upon as a dreamer; thus his career as a tool maker in Manchester did not afford him the same opportunities of setting out into the world those lasting monuments of his genius as fell to some of his contemporaries.

Evolution of Planing Machines.

What was looked upon as the most important and probably the immediate offspring of the slide rest was the planing machine. A machine which it has been said has done more in reducing the cost and extending the use of machinery than the other improvements effected in mechanism, there being few machines or engines in which the plane surface is not foremost essential to perfect action or not most frequently required.

The vast expense attending the production of a plane surface by the tedious process of chipping and filing caused most of the early engineers to avoid all construction which rendered such forms necessary. This practice was, however, soon altered on the introduction of the planing machine, which did for the plane surface what the slide rest had effected for cylindrical forms; the result being that machinery produced by its agency was not only infinitely superior, but improved tools were made at a far less cost as the first planing machine helped in the production of still better second, and that again a still better third, so that an entirely new branch of engineering became established; viz. that of machine tool making.

Now as the early engineers when called upon to supply, or if they required it for their own use, a tool of an entirely new type, had no precedent to guide him as to the parts actually necessary in such contrivance, or as to form the machine or its parts should assume, it is not surprising to find that the earliest machine for metal planing should have been given varying forms, although embodied in them were the same fundamental principles and modes of action. The parts common to

the earliest of them were principally two in number, viz; The bed on which a table carrying the work to be planed was caused to slide backwards and forewards on guides, and a main slide carrying a transversing one in a tool holder, which was held in position by being bolted at its ends to upright standards, attached to the machine bed on either side. A to and fro motion was usually imparted to the table of the early machine by a chain wound round a drum, which was revolved first in one direction, and then in the other by hand.

As to the orginal inventor of the planing machine there is perhaps scarcely a machine about which there has been more controversy than this, and there are many claimants to the honor. There are records showing that Nicholas Forq, a French clock maker, used a metal planer in 1751 for machining pump cylinders, apparently being under the impression that they could be made more accurately in this manner than by revolving cutter.

Roberts' Machine.

Richard Roberts, of Manchester, coustructed a planing machine on an original plan of his own in 1870. This machine is said to be the first one ever made for the planing of metal, and is exhibited at the South Kensington Museum. That the machine may claim for itself priority of existence over any other devised for the same purpose, is evidenced by the hand tool and other marks to be seen on its bed, which plainly shows that no previous planer had been used in its construction.

On an inspection of the illustration (Fig. 4) it will be noted that the bed of the machine consists of two cast iron sheets, of angle bar form, stiffened by bracketing, and bolted to cast iron supports of the form shown. The table traverses on inverted V guides on

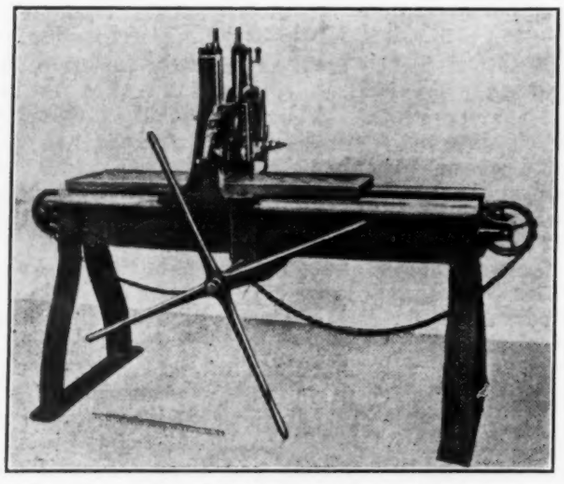

FIG. 4—*Roberts' planing machine.*

the bed top, and is moved by hand to and fro by means of a chain passing over sheaves at the ends of the bed and wound on and off the drum of a winch placed midways, in the length of the bed—this being turned by the four armed handles as shown. There are two uprights to carry the cross slide, to be firmly bolted thereto and to form the guides when raising or lowering the cross slides.

Clement's Machine.

It is to Clement, however, that the honor is usually credited of bringing out the first iron planer on the same lines as the tool is now built. He had a machine for planing the triangular beds of lathes in 1820, and in 1825 built a more elaborate one, which is described in a paper read before the Society of Arts during the session of 1831 to 1832.

This paper commences as follows: The engineers' planing machine is used to cut metal so as to produce clean and perfectly straight or flat surfaces. It differs greatly from the carpenter's tool called the plane, the length and straightness of which prevent the cutter from descending into any hollows; it therefore gradually reduces the prominences, and the cutter is never allowed to project through deeper than the thickness of the shaving, which the workmen can safely take off without tearing up the grain of the wood. The wider such a plane is, the flatter it will work, but as the resistence increases with the width of the cutter, this latter rarely exceeds two inches or two and one-half, for beyond that, the weight and strength of a man are not sufficient to overcome the resistence.

After thus preparing the minds of the members for the existing conception of the planing art, the paper goes on to say: The planing machine about to be described, bears more analogy to the turning lathe; it performs its work in straight lines, and is so constructed that during longitudinal cuts, the tool is stationery and the work moves, but during lateral cuts, the tool moves. The tools or cutters are similar to those used at the lathe; their forms being in like manner varied from a strong point to a chisel shaped edge to finish the work.

Clement with a view to remove as far as possible the friction and labor due to the travel of the table, caused the table of his machine to pass under the cutting tools on rollers or wheels, which were held in accurately made bearings having set screws acting against the ends to prevent all endwise motion. He also saved or used the whole time by taking cuts both ways, there being two tools mounted in the tool box—one to cut while going, the other while returning, as the description explains the to and fro movement of the table.

Clement clearly recognized the necessary conditions under which planing could be correctly done. As can be imagined, freedom from friction in moving the table and the pieces to be planed was of far greater consideration than at present. Hence the table on friction rollers. But rigidity in the parts and perfect fitting of the bedding surfaces, are clearly specified as necessary to destroy all tendency to vibrations, and there obtain full, sound, and quiet cuts.

It is very easy now, after many years' experience, to see where Clement failed to embody that rigidity he had in view; but in other ways we cannot help appreciating the feature of a good and solid foundation under his machine. The language of the paper is particularly clear when it says it was requisite to obtain a very perfect base to build on, one that would not bend, spring or yield in any way to the most unequal loads that were liable to be put on it.

Mr. Clement began by laying in the earth an artificial rock, or bed of masonry, with an iron surface large enough to give confidence to the superstructure. Confidence, as referring to the stability of the parts of the machine, is a rather happy expression. One of Clement's original drawings showing side view and details of this machine, is reproduced in Fig. 5.

Looking at this view, we must at once realize the side weakness of the whole construction. Instead of a bed to support the table and tie the uprights together at the bottom, we have the space occupied by the roller wheels to carry the table. The uprights are also without much stiffness in the direction of the cuts, being quite parallel from bottom to top, evidently to accommodate the clamping plates which hold the cross slide. The description of the machine gives these uprights good character, as they are referred to as strictly upright standards.

The table is driven by two racks, with small pinions which are apparently solid with the shaft. There are no complications in the driving of the table, as a large pulley is keyed directly to the rack pinion shaft. This is driven from an overhead counter-shaft carrying a reversing motion in the shape of three mitre wheels and a sliding claw clutch. At the end of the stroke the machine reversed automatically.

Clement mounted his cross slide in trunnion bearings at each end so that by tipping this slightly at the end of each stroke, the tools at the back and front on the cross slide could be brought into position for cutting. The section shows the left-hand tool in position.

Clement had also various attachments to his machine for turning, milling, gear cutting, and rack cutting. Clement's planer was the most useful machine and did much towards advancing engineering work at that time. For 10 years after it was set in motion, it was the only machine of the sort available for planing large work, and being very much in request, it was often kept going day and night. This machine was in use as recently as 1870, about which time all Clement's plants were sold at public auction.

Bodmer's Open-Side Planer.

The logical method of making a planer to get the

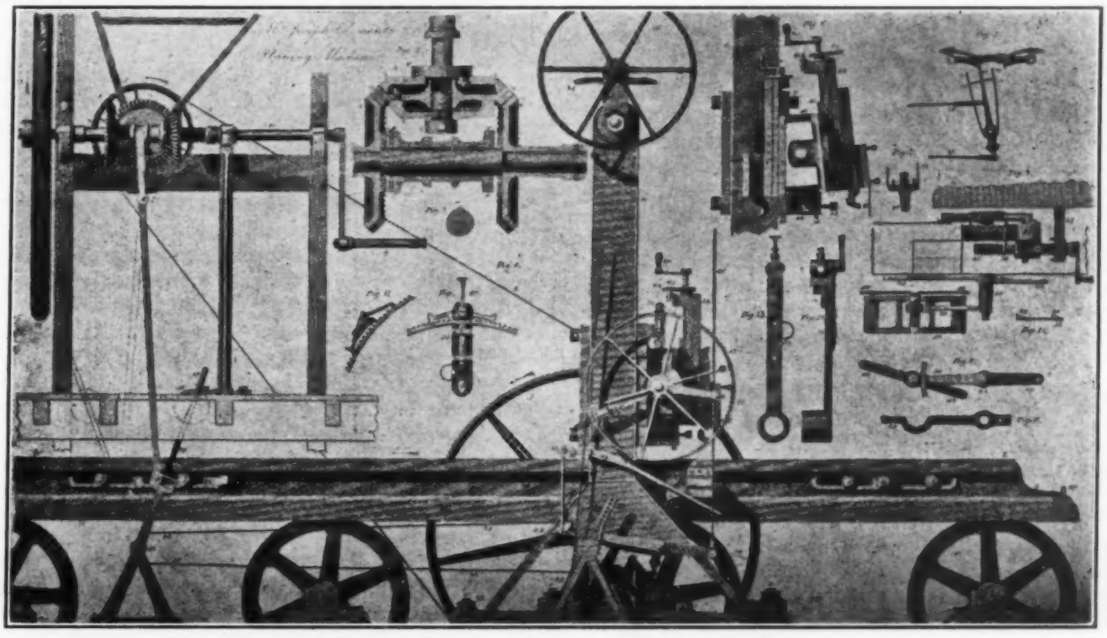

FIG. 5—*Clement's planing machine. Side view and detail.*

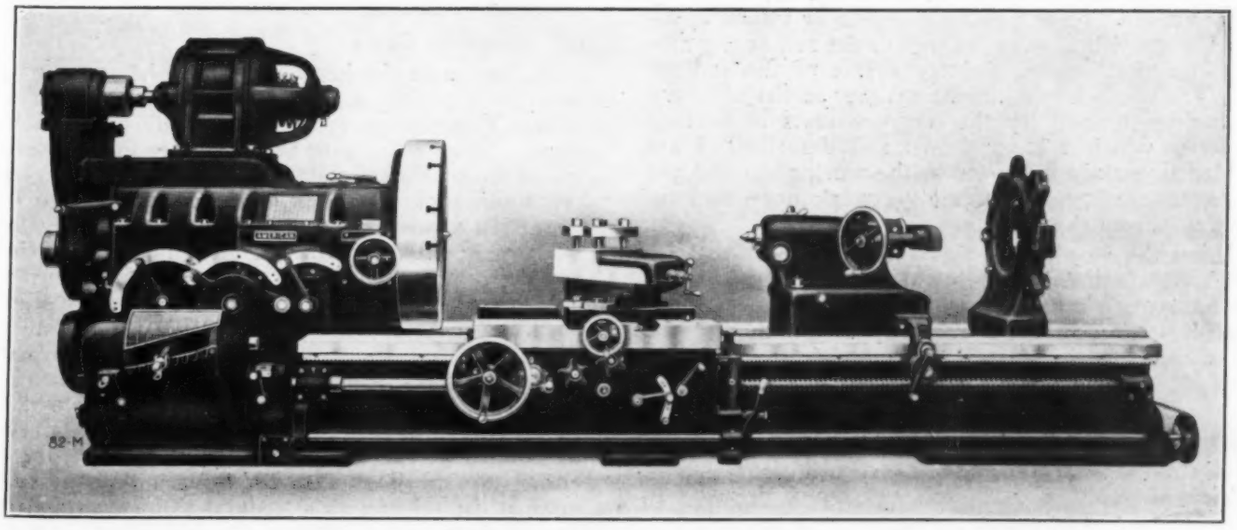

FIG. 6—*36-in. high duty lathe.*

greatest amount of rigidity to the tool slides and supports was to set up two vertical frames on each side of the table, and put the cross slide on the front of them. That this was correct theory is shown from its being the type that is universal today. But it is limited in taking in pieces that will pass between the uprights. This form of machine, however, did not enable large and irregular pieces to be planed, and it became evident that other forms of machines were necessary to deal with these. Therefore, it is with interest we now consider the type of planing machine as shown in Bodmer's patent of 1839. It is what is termed an open side planer, and planes horizontal and vertical surface. The tool box at the end of the overhanging arm swivels to bring the tool to suit surfaces at any angle and shape, and the upright column also swivels on its base, so that an additional set of conditions are brought to bear in the application of the machine to pieces of almost any shape and size.

The moving of heavy pieces, however, did not comment itself to engineers here, and instead of following Bodmer's type, it was condemned as faulty in principle. The class of planing machines known as wall planing machines, in which the tool has horizontal and vertical movement, while the piece of work is placed on the floor in front of it, has been considered more practical than moving the heavy pieces to be planed.

Hulse's Open-Side Planer.

Here it is interesting to note the open-side planer in which the work is fixed and the tools travel, patented by Hulse in 1865. In this same patent there were included other types of machines with traveling tools, and the description is so clearly put in the specification, that we will take an extract from it.

Instead of fixing the work to be planed on a traversing table, and employing stationery uprights as hitherto adopted, I fix the work to a stationery bed or table and cause the uprights and cutter to traverse along it. The work to be planed is fixed to the bed or table, at the sides of which are longitudinal slides extending the length of the bed, and in which are placed the lower parts of the upright, which are well stayed at the top and carry the cross slide and one or more tool holders. The uprights are propelled to and fro longitudinally by screws worked by pulleys and spur gearing, the pulleys being driven by open and cross straps, which are shifted as required by strap forks, worked by the moving uprights by means of inclined stops, which stops, as well as the self-acting motions, for the vertical and transverse of the tool or tools, are worked in a similar manner in the ordinary planing machines. By the improvements in planing machines which I have shown and described, I am enabled to economize space in the work shop and obtain great facility in placing the work upon and removing it from the machines.

From the wording of this specification, it appears as if Whitworth did not proceed with the development of his traveling upright machine, 1835 patent, as those of Hulse came on the scene 30 years after, and the statement is made of stationery uprights as hitherto adopted.

MODERN PRACTICE*

Lathes

In this lathe is offered the very latest development in high duty lathes, both belt and motor driven. In the design we have is embodied certain improvements which were incorporated only after long and careful study of present day requirements for heavy service. These new features are of the utmost importance and deserve serious consideration by anyone desiring to install the most efficient and productive equipment.

Patented 18 Speed Geared Head.

The patented 18 speed geared head is unusually powerful as the belt will normally transmit approximately 35 hp. The head may be arranged either for constant or variable speed motor drive. For either single pulley or constant speed motor drive installations, 18 changes of spindle speed are provided, while for variable speed motor driven lathes the head is simplified through the elimination of certain of the driving mechanism. With this latter arrangement the head has six mechanical speed changes, a motor speed variation of 2 to 1 providing the full range of spindle speeds.

If it is desired to have the maximum speed variation through the electrical apron control, either a 3 to 1 or 4 to 1 motor may be used to advantage.

If these lathes are motor driven they should be equipped either with 25 h.p., 30 h.p., or 35 h.p. motors, according to the nature of the service. For maximum requirements the latter h.p. is recommended, as the drive is amply powerful enough to work continuously under the full overload capacity of a 35 h.p. motor.

The motor drive connection is through herringbone gears, which are made of steel forgings. These gears are fully enclosed and are continuously flooded with oil. A flexible coupling, placed between the motor and the driving pinion compensates for the end movement of the armature shaft and insures quiet running gears. The motor pinion is mounted on double race self-aligning ball bearings.

The 18 spindle speeds provided on the constant speed drive are obtained by 16 gears, including the face plate, internal gear and pinion, while only nine gears are used for the six speeds of the simplified head for variable speed motor drive. All mechanical speed changes are obtained through sliding or clash gears, neither friction nor jaw clutches being used. Thus, all of the speeds are selective. The only gears in use at any time are those actually transmitting power — consequently, there are no idle running gears or sleeves in the head and the possibility of such elements "sticking or seizing" is eliminated.

Oil Tempered Gears.

All gears in the head, including the triple gear or face plate pinion, are made of a high carbon alloy steel. These gears are oil tempered (not case hardened). After hardening the bores are ground concentric with the pitch diameter by means of a special four-jaw tooth segment chuck which equalizes such slight distortion as may occur in the hardening process, and enables producing gears, the pitch lines of which will not run out of true more than one-half thousandth, even on the largest gear. The average tensile strength of these gears is approximately 200,000 lbs. and the Brinell harness about 385. This method of treatment produces gears which not only have an extremely hard surface, which will not chip, but also a very tough core, which is practically proof against crystallization. The characteristics of these gears, after hardening, are well illustrated by bending one tooth against the other with a sledge hammer, without fracturing them.

*Contributed by American Tool Works.

Heat Treated Spindle.

The spindle, as well as all other shafts in the head, is made of a high carbon alloy steel which is heat-treated before machining, and the spindle and shafts run in a special composition phosphor bronze, which has unusual wearing qualities.

Face Plate Drive.

The most remarkable feature of this new geared head, is in the arrangement of the face plate drive, as two-thirds of the entire range of speeds is transmitted through the internal face plate gear. In other words, only one-third of the spindle speeds are transmitted direct through the spindle — consequently, for all severe turning operations the drive is through the internal gear in the face plate.

This characteristic cannot be emphasized too strongly, as most other geared head lathes with internal face plate drives transmit only one-third of the entrie speed range through the face plate gear, the highest internal gear speed on the average lathe of this size being approximately 10 r.p.m. This greatly limits the diameter of work which can be driven through the face plate at efficient cutting speeds.

On this new model lathe all speeds up to and including 32½ r.p.m. are transmitted through the internal gear face plate drive. The above speed provides approximately 50 ft. cutting speed on a 6-in. diameter. It will therefore be evident that all roughing operations 6 in. and larger in diameter can be performed at 50 ft. or greater cutting speed, while driving through the face plate. It is therefore only necessary to drive direct through the spindle for comparatively light operations at high speeds.

It is highly desirable, in a face plate driven geared head lathe, to support all of the driving elements as rigidly as possible. Therefore, all of the gears and shafts have been embodied in the lower half of the head. The upper half merely serves as a cover and also a support for the motor.

Automatic Oiling System.

The automatic oiling system, which has proven so successful on the smaller sizes of lathes, has also been incorporated in this new head. The oil is pumped by a gear driven oil pump, from a reservoir at the bottom of the head, to a distributing chamber in the top cover. Before the oil reaches the bearings it must pass through a felt filtering pad in the distributing chamber. It then drips into small reservoirs from which it is fed through tubes to the various bearings. Each tube has its individual reservoir so as to prevent any one bearing from absorbing the oil intended for the other bearings. In other words, the oiling is really selective, in the sense that each tube receives its proportionate amount of oil.

A sufficient overflow from the distributing chamber also lubricates the gears. The oil then drains back into a suitable settling basin from which it overflows into the primary filtering chamber and is then drawn through a fine wire mesh filter and again pumped to the top of the head. Thus a copious flow of clean oil continuously lubricates all of the mechanism in the entire head. This system is manifestly superior to either the splash system or the "hit or miss" squirt can system of oiling.

From the foregoing it will be evident that the entire head mechanism is as nearly fool proof and accident proof as possible, the only attention required being an occasional cleansing and renewal of the oil supply. Otherwise, the entire mechanism in the head is self-sustaining, as the gears are practically indestructible.

Starting Clutch and Brake.

The starting clutch and brake are incorporated in a detachable unit which is located in the driving pulley of belt driven lathes or in the large motor gear of motor driven lathes. The unit is fully enclosed and the clutch and brake mechanism operates in a bath of oil.

Mechanical Apron Control.

A mechanical apron control for operating the starting clutch and brake is furnished as regular equipment. This is operated by a lever located on the right hand side of the apron, by means of which the operator is enabled to instantly stop and start the spindle, from his position at the apron.

Electrical Apron Control.

For variable speed motor driven lathes, having a fairly long bed, it is desirable to equip the machine with an electrical apron control in addition to the mechanical apron control. This combination enables the operator not only to vary the motor speeds from the apron position, but also permits him to start and stop the spindle independently of the motor, for examining or callipering the work, after which the spindle can instantly be brought back to its working speed.

The Bed.

The bed has been greatly widened and otherwise strengthened, the center distance between the carriage vees having been increased from 26 in. to 31¾ in. The center distance between the tailstock vees also has been proportionately increased. This increased width is especially advantageous if it is desired to increase the normal swing of the lathe by raising the centers either with raising blocks or otherwise. In addition to widening and strengthening the bed, the carriage bridge has been increased in width from 13 in. to 16 in.

The Tailstock.

The tailstock also has been strengthened and improved. The spindle adjusting hand wheel has been placed in a much more convenient location, near the front or left hand end of the tailstock, and is connected to the spindle through an angular shaft and bevel gears. This arrangement gives the operator a much more convenient control of the spindle, either for centering his work or for boring operations.

Power Rapid Traverse.

A power rapid traverse to the carriage is a very desirable feature on long bed lathes and especially for turning long shafts. This power traverse mechanism is not regularly furnished but is offered as an attachment. It can be applied either when the machine is build or at any time after installation, as the carriage mechanism is regularly arranged to receive it.

The rack pinion is withdrawable from the rack—a very desirable feature when cutting coarse pitch threads. The pinion has a bearing on its inner end beyond the rack, consequently there is no overhang. The feed rack is 2 in. wide, 4/5 p. and is made of a high carbon heat-treating material.

General Specifications.

In addition to the improvements referred to in the above, this new design also embodies the following features, which are now standard equipment on all sizes of these lathes.

Renewable Bronze Bushings.

Renewable bushings are fitted into every cylindrical member subject to wear, throughout the entire lathe. This applies to all bearings, sleeves, loose gears, etc. Therefore, the life and accuracy of alignments can be indefinitely prolonged by renewal of the bushings when worn. This lathe is more complete in this respect than any other lathe. To enable convenient renewal of worn journal bushings the bronze liners are fitted into cast iron sleeves, which in turn are firmly seated in the housing. When necessary these sleeves may readily be removed and re-brushed. these sleeves may readily be removed and re-bushed. This enbales a most convenient and reliable method of renewing worn journals.

Spindle Bearings.

The spindle bearings are made in halves, the caps being given a solid metal to metal contact with the head, and laminated shims are placed between the cap and the head. In order to take up wear in the spindle bearings the caps must be removed and one or more laminations taken out, according to the amount of wear. This not only provides a most reliable means for taking up the wear, but also effectively prevents the operator from tampering with the adjustment of the bearings. These bearings are given a proper running clearance before leaving the factory, and will run for years without further attention.

Quick Change Gear Mechanism.

This mechanism provides a very wide range for screw-cutting. However, should it be necessary to increase this range, a convenient means is provided, through the auxiliary quadrant on the end of the bed. This quadrant enables applying additional gears for cutting special or coarse leads, consequently the screw-cutting range is practically unlimited. The quick change gear mechanism is embodied in a separate unit on the front of the bed, where it is quickly detechable and easy of access, should repairs become necessary.

Steel Gears.

Steel gears are furnished throughout the entire machine, those gears subject to severe service being heat-treated and hardened.

Apron.

The apron is of complete double wall construction, consequently all studs are rigidly supported on both sides of the gears. The bearings are lubricated from a channel at the top of the inner wall, from which the oil is fed through felt filters and tubes to the various bearings. An interlocking device makes it impossible to engage the feed mechanism and half-nuts simultaneously.

Lead Screw.

The lead-screw is 2½ in. in diameter, one thread per inch. It is made from a high carbon special screw stock, which is ground to size before machining. The threads are first roughed out to within .015 in. of their finished size, after which the screw is laid aside to season. It is then finished from a master screw in a special lead-screw lathe, and is guaranteed to be accurate to within a limit of .001 in. per foot, for its entire length.

Demands of Lathe Users.

The market today offers as great a variety of types of lathes as there are holes in a sieve.

Accuracy of work is getting to be more and more in demand which, therefore, requires, first, ruggedness of design; second, convenience of operation; third, that nicety of construction to insure accuracy of work produced, and this applies in particular to lathes of the smaller sizes and of the motor driven type.

The so-called old style, well tried out, cone type of headstock, which has always proven to be the best

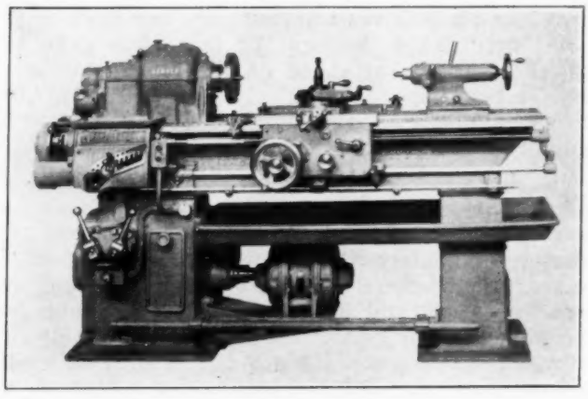

FIG. X—*One of the modern motor-driven lathes.*

design for general purposes owing to its simplicity, has almost been lost in the shuffle owing to the demand for motor driven lathes with headstocks containing an overburdened amount of gears, resulting very frequently in work showing tooth and chatter marks which cannot be overcome no matter what care is exercised in the cutting of the headstock gears.

The desirable construction of a motor driven lathe, if possible, is to retain the well tried out design of the cone headstock with its simplified back gears, and interpose a speed change gear box, which could be connected to spindle by single pulleys and wide belt, and locating this speed change gear box in the cabinet leg under headstock, connecting motor direct to gear box through a gear reduction if necessary, and with this low position of gear box and motor the lathe would not be affected by any slight tremors from these driving members.

The above arrangement would further result in that very desirable feature same as obtained from a cone type belt driven lathe, namely, the resiliency of the driving belt between spindle and gear box would dissipate the action of the gears in speed change gear box, and would produce work free of chatter and tooth marks, same as the results obtained from a cone head lathe.

The above suggestions also offer the advantage to operate spindle through open belt or through the regular back gears similar to a regular standard belt driven cone head lathe, which has always proven so popular for the reason that same does not have the faults very frequently found with the all geared type of lathe.

REVERSING PLANERS

Why Direct Motor Drive Pays.*

You get these advantages: Freedom from losses due to belt troubles; no time lost in slippage, no time wasted in tightening, no losses from belts burning; safety; more power at the tool; greater overload capacity; cutting speeds maintained in uneven cuts; fine graduations of speed with independent adjustments for cuts and return.

Belt troubles have been particularly bothersome on planers because of the great wear, particularly when

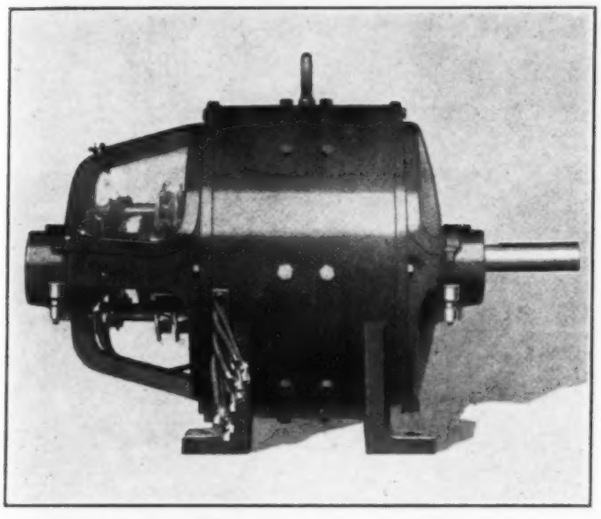

FIG. 7—*Modern reversing planer motor.*

taking short strokes. Shifting belts have always been a big problem for the designers of planers. A belt must be selected that is narrow enough to shift easily and without excessive wear and at the same time be of sufficient width to drive the planer to capacity. As a result driving belts on planers are smaller for the h.p. transmitted than on other types of machine tools. On planers requiring more than 15 h.p., it will be found that the belt wear is excessive. Even for planers requiring only 10 h.p. or 15 h.p. the manufacturers recommend direct motor drive if the work is heavy and the planer is to be operated to capacity.

Output Limited by Belt Drive.

Planer belts when new and in perfect condition may transmit the power required. There is no leeway in the design, however, to make up for the changes which quickly occur due to stretching, burning and wear. Production must suffer due to slippage or through time lost in tightening and repairing. Being limited in pulling power, the users of belt-driven planers have not obtained the full advantages made possible by improved cutting tools. Heavier cuts may have been taken but little has been gained. The limited belt capacity has resulted in greater slippage and, therefore, slower cutting speeds and greater belt wear. Operators have "nursed" rugged machines which could easily be taking much heavier cuts and turning out more work with lowered costs. Planer manufacturers recommend direct motor drive because they know that the user will get greater output with lower costs.

*Contributed by Reliance Electric & Engineering Co.

Few Speeds With Belts.

The usual practice has been to give one cutting speed and one return speed on belt-driven planers. On some planers cone pulleys have been used giving as many as four cutting speeds. In both cases, however, the speeds were fixed and but one return speed was provided.

A Variety of Speeds With Motor Drive.

Even assuming there are no troubles with belts, the direct connected reversing motor drive will show a greater production by increasing the range and number of working speeds. These can be arranged for 25 to 60 feet a minute for cutting, with at least 20 intermediate speeds and 50 to 100 feet for the return stroke with the same number of intermediate speeds. It is possible to have any combination of cutting and return speeds within the range of the equipment. The adjustment for the cut stroke is entirely separate from the return stroke.

Getting Maximum Output From Planers.

Metal planers cost a lot of money, occupy much floor space and require skilled operators. They usually occupy a place of first importance in the production process. Saving time and increasing output on such machines is, therefore, of special interest to every man responsible for production.

With the improvement in the design of planers and cutting tools has come a demand for a drive to meet the following requirements:

1. A simplified and positive drive that will deliver ample power under all conditions.

2. A means of speed adjustment to provide the best combination of feed and cutting speed to insure top-notch production on a variety of work.

3. Maximum return speeds to cut down the non-productive time inherent in reciprocating machines such as planers.

Slower return speeds for extra large or top-heavy castings.

4. Facilities for reducing set-up time on large castings.

As with many other types of machine tools, the electric motor with suitable control equipment has best met all of these requirements.

Features Required in Motors.

Reversing planer service makes certain demands upon the driving motor beyond that which is required for most machine tools.

1. The motor should be of rugged mechanical design to withstand the strains of the heavy service and frequent reversals. Liberal bearings and large shafts are especially important.

2. Armatures must be longer and smaller in diameter to reduce the flywheel effect and quicken the reversal.

3. Special care must be given to armature slot insulation and holding the coils in place securely. Frequent changes in the direction of rotation cause an extra strain on coils and insulation.

4. Windings must be designed to insure good commutation under rapid reversing service. They must also withstand high current peaks at time of reversal and heavy overloads caused by extra heavy cuts.

Advantages of Direct Motor Drive and Automatic Reversing Control.

The advantages provided by direct motor drive with automatic plugging control are:

1. All the usual advantages of motor drive on machine tools, such as clear overhead, better light, a positive drive and ample power.
2. The elimination of belt troubles.
3. Accurate speed adjustments provide a 1 : 2 range of cutting speeds, usually 25 to 50 feet a minute on standard planers.
4. Separate adjustments for return strokes from 50 to 100 feet a minute.

Quick return strokes on light work reduce the non-productive operating time to one-third that of belt drive.

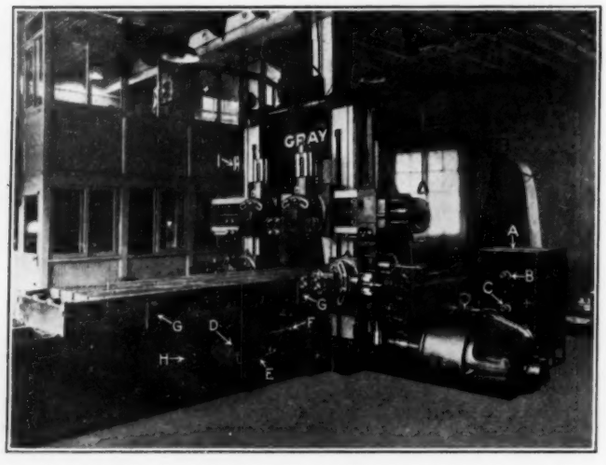

FIG. 8—*36-in. by 36-in. by 10-ft. maximum service planer, driven by 15-hp. 250/1000 rpm. reversing planer motor.*

Slow return strokes are available for bulky castings.

5. The ability to plane accurately to a line or shoulder.
6. A big saving in set-up time on large castings.
7. Much lower production costs, resulting from the six advantages listed above.

Control—See Figs. 9 and 10.

Method of Operation. — The operator pushes a button to start the planer and pushes another to stop. Aside from this the controller is entirely automatic in operation, every movement being governed by the drum master switch (D).

One of the rheostats is set to give maximum results for cutting, the other for a suitable return speed depending upon the weight or size of the work. A range of 1 : 2 is provided for each. This usually results in cutting speeds of 25 to 50 feet a minute on standard planers.

For setting-up, the operator pushes the "pendant" button on the transfer station (C). This disconnects from the circuit entirely the drum master switch on the bed. Regardless of the position to which it may be thrown, it has no effect on the movement of the planer table. The control is entirely in the hands of the operator through the pendant switch (E). The motor can operate only while one of the buttons is held down. The table can be moved as little as 1/16 in. or moved its entire length in either direction. When setting-up is complete, the operator pushes the "drum" button on the transfer station which again transfers the control to the drum maser switch.

Quick Stopping.

Dynamic braking provides quick stops whenever the "stop" button is pressed or when a circuit breaker trips on overload.

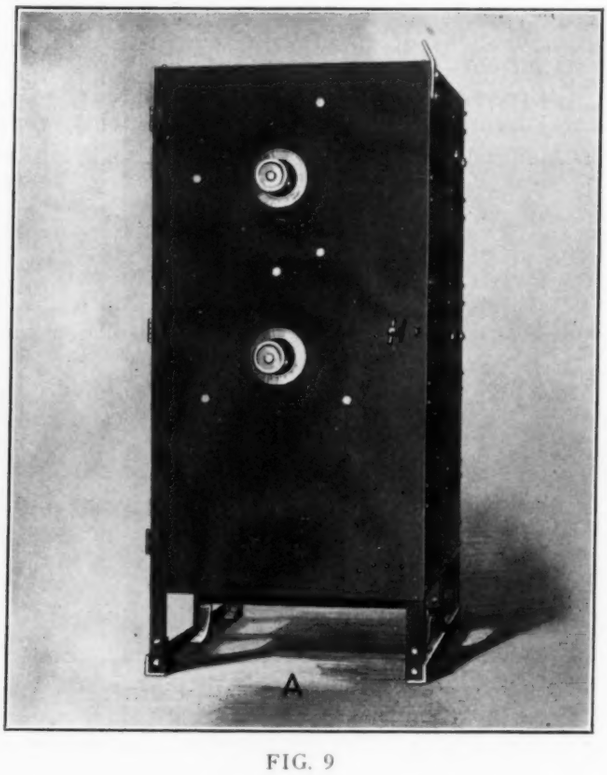

FIG. 9

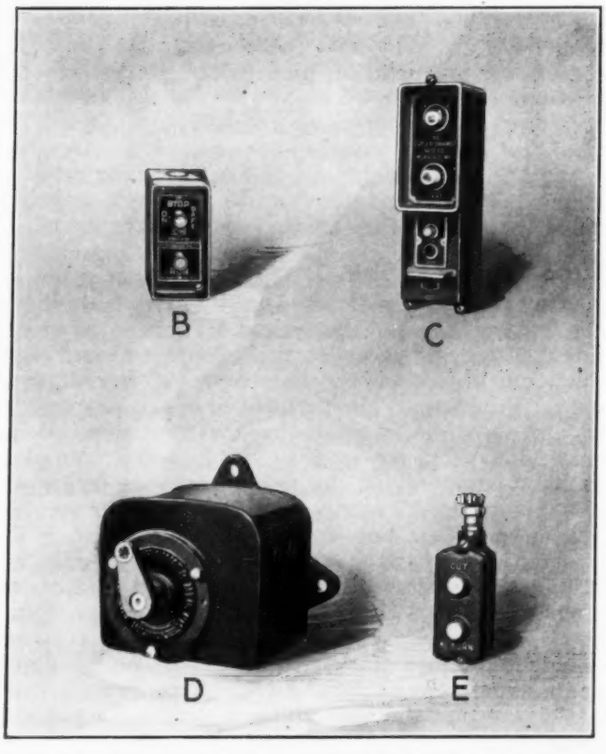

FIG. 9 and 10—*Automatic planer controller with accessories.*

Low-Voltage Protection.

If the equipment stops because of voltage failure, it will not restart until the operator presses the "start" button at (C) regardless of the setting of the transfer station.

The control panel is provided with a voltage relay which will open the circuit breakers whenever the outside voltage supply falls to 80 per cent of normal. The

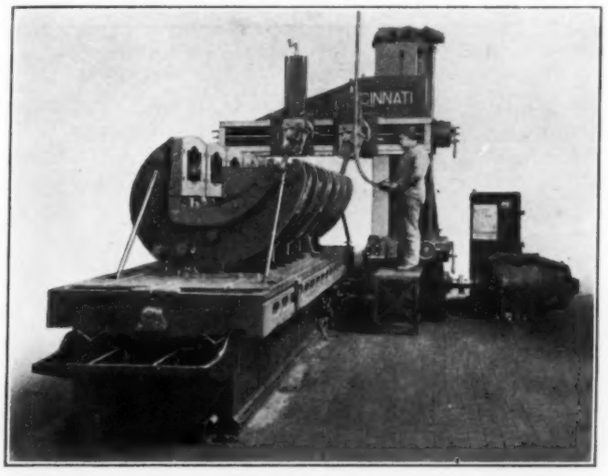

FIG. 11—*60-in. by 60-in by 16-ft. open side planer.*

arrangement is such that dynamic braking action will occur for either direction of travel whenever circuit breakers open.

As an emergency stop where frequent interruption of the current supply may occur, a magnetic brake can be supplied. This is mounted on the end of the shaft and so connected that it acts when the "stop" button is pressed or an overload or failure of current occurs.

Plugging Method for Reversing—This controller utilizes plugging for reversing instead of dynamic braking. This simplifies the controller and its operation. It has a time-saving advantage over dynamic braking in that power is applied to the motor all the

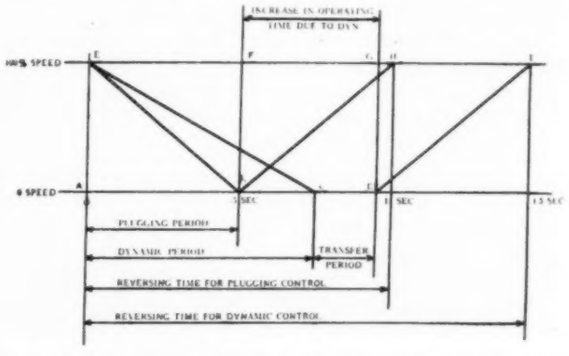

FIG. 12—*Chart showing dynamic braking and plugging method of control.*

time during reversing from full speed in one direction to full speed in the other. The time required for reversal is less because less time is required for stoping and there is no change-over period in the controller. Just what this means is illustrated by Fig. 12.

The more rapid reversal obtained with the plugging method, necessarily results in a proportionately greater power demand at the instant of reversal. This is of little importantce when the time-saving advantages are considered.

Greater accuracy of control at time of reversal is obtained with the plugging type of control. There is less over-travel at the end of the stroke. This is of importance when planing to a line or up to a shoulder, and on short stroke work.

The chart shown in Fig. 12 is prepared from the results of tests made to determine the time required for stopping and reversing by both the dynamic braking and plugging method of control.

The line E-B shows stopping time by the plugging method. Line E-C the same by dynamic braking. With the plugging control the motor is back to full

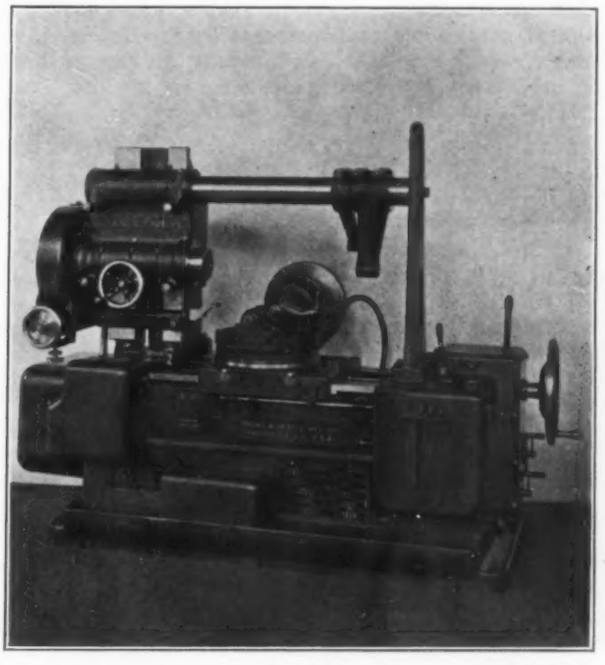

FIG. 13

speed in the opposite direction at H. B-C indicates the extra time required for stopping with dynamic braking and C-D the time lost in the operation of the controller changing from dynamic to power when motor is stopped. This saving of time is a factor in increasing the cutting time and adding to the productive efficiency of the planer.

HORSEPOWER REQUIREMENTS FOR REVERSING PLANERS

The table below gives the approximate horsepower capacities required for the efficient operation of various sizes of planers in general use.

Planer Size	Medium Duty
36-inch	15-25 h.p.
48-inch	20-35 h.p.
56-inch	25-35 h.p.
60-inch	25-35 h.p.
72-inch	35-50 h.p.
84-inch	35-50 h.p.
96-inch	50-75 h.p.
120-inch	50-75 h.p.
Frog & Switch	50-75 h.p.

Many curves and figures taken from actual practice might be submitted showing quicker reversals being made with the plugging method of control as com-

pared with dynamic braking. To anyone in doubt we suggest the following as the simplest and most satisfying test. Watch both types of control in actual operation. Place your hand on the planer table. Note the quick but smooth action of the plugging equipment at the time of reversal. We are confident that after such a test no further consideration of theory or curves will be necessary to realize the time-saving advantage of the plugging method.

GEAR CUTTING MACHINES*

This company has been manufacturers of automatic gear cutting machinery since 1880 and now manufacturers four types and seven sizes.

The range of these machines (the spur gear type) takes sizes from the smallest that might be used on general machinery and automobiles, to 72 in. in diameter, which size is used on rolling mill gears, hoisting machinery gears, etc., etc.

The bevel gear machinery, of which they make two sizes, is limited to 24 in. diameter but these machines are also used for cutting spur gears and clutches as well as bevel gears and are especially adapted to those shops where one machine is sufficient.

Of hobbing machines they make two distinct types: the No. 44 is for spur and spiral gears, while the No. 34 is a single purpose machine for spur gears only and as splined shafts are similar to spur gears it is particularly well adapted to this work.

These two hobbing machines were designed with the automobile in mind and they are particularly well

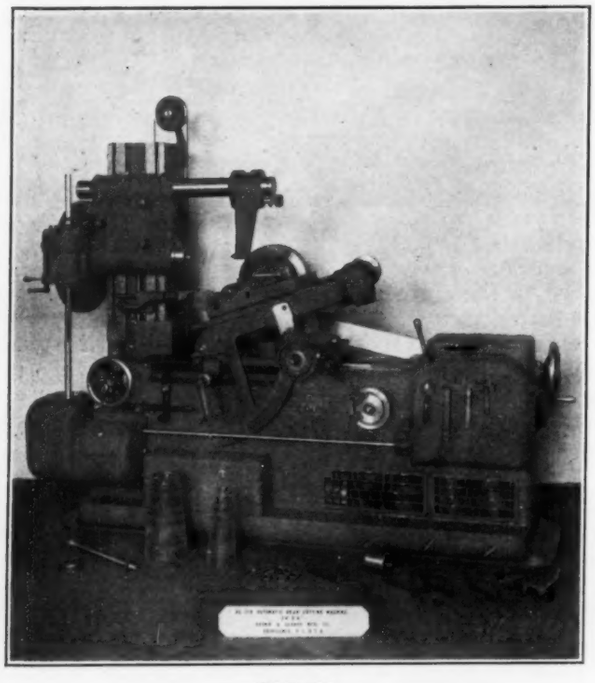

FIG. 14

adapted for cutting transmission and timing gears. The No. 44 machine is equipped with a differential which makes it possible to change the feed at will when cutting helical gears without recalculating the index gears. The No. 34 machine is as stated before, a single purpose machine with a minimum number of gears in the hobbing train, at the same time a machine that can be changed quickly to cut any gear within its range.

The design of the machines is such that they are very simple to operate; the work can be easily mounted on them; the tool cost is well defined as the cutters are carried in stock by all cutter manufacturers.

The experience we have had covering so many years, both as manufacturers of a wide variety of ma-

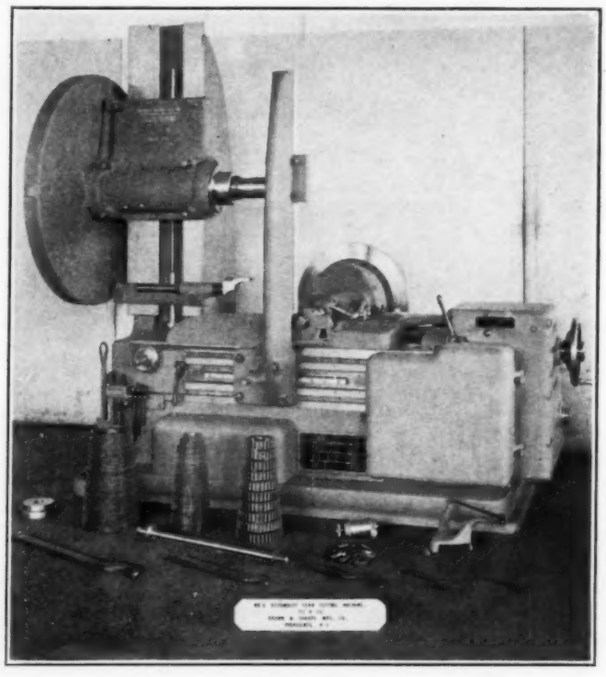

FIG. 15

chine tools and as the first manufacturers of cutters (the backed-off or formed cutter such as is used for all gear cutters, and hobs were invented by the founder of this company in 1867) has enabled us to design machines that permit the cutters to give their maximum service. This will be appreciated by all users of machine tools, and often times breakage in the cutting tools is due to the lack of stability in the machine tool rather than in the cutter.

Perhaps a reference to certain features of design characteristic to all this company's machines will be of interest.

As is known, unless a gear cutting machine is of good design, that is, of such proportions as to be rigid and capable of taking heavy feeds, durable to last under this service, easy to handle, and, after all this, to be well and accurately spaced, it may be next to useless as a gear cutting machine. It is well known that the inaccurate gear has very little standing nowadays, as it does not cost much more to cut a good gear than it does to cut a poor one and good gears are only produced on machines having the qualities of accuracy, stability, durability and easy handling.

Fig. 17 shows a section through the cutter spindle, and illustrates very clearly how it is constructed, and how readily it can be adjusted for end play or oil space, if this ever becomes necessary. Note the spindle gear is riveted to the driver "A" and the driver "A" is carried in the cover plate "B", which is turned and fitted to the housing "C". Now this feature is

*Contributed by Brown & Sharpe Mfg. Company.

a very desirable one for this reason. You will note the fly wheel is fastened to the tapered end of the spindle itself, as it should be, and the spindle is fitted into the driving sleeve at "D". As this driving sleeve is a close fit in the driver "A", the weight of the fly wheel is really carried by the bearing in the cover plate "B", so you can see that the spindle bearing at "E" is not stressed with the weight of the fly wheel. Also, the spindle does not carry any bending stresses due to the weight of the spindle gear or the radical thrust due to the teeth of the spindle gear and worm, which is considerable. The driving worm is of steel hardened very hard, and the threads automatically ground, and fits the six splined driving shaft as shown. Note the hardened steel thrust plate at "F" to take the thrust of the driving worm. This section shows very clearly the rigid bed and the cross-ribbing placed at close intervals the full length of the bed. The guiding way is long for its width, and the strap on the outside holds the slide down against any tendency to lift as the cutter enters the blank. The location of the feed screw is ideal, being about mid-way between the cutter and the grinding way, and below the guiding way. The ample spindle bearings, their ease of removal for repairs or replacement, and closeness of the bearings on each side of the cutters, so necessary in milling operations, is apparent. A complete spindle assembly is on the bench for your inspection.

Fig. 18 shows a section through the feed case. The ease with which the working parts can be removed or re-assembled is quite apparent, and an effort has been made here to so design them that any mechanic

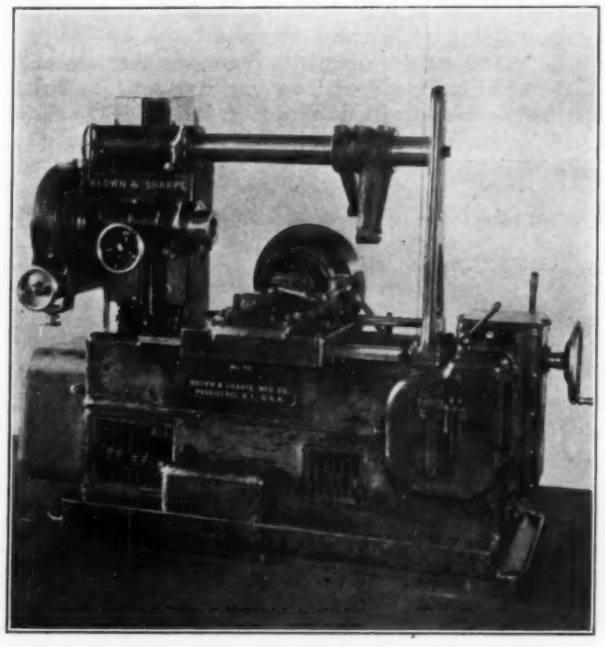

FIG. 16

can take care of them. The method used in holding on the speed change gears is as follows:

The back of the gear hub is slotted and fits the milled or tongued shoulder of the shaft. The split washer, against which the clamping nut bears, is also slotted and fits a tongue on the end of the shaft. The reason for slotting the split washer is to prevent any play between the slot in the back of the gear and the tongue on the flange from loosening the clamping nut which holds the gear in place. That this is needed on a machine of this type (that is, "milling type"), is very apparent, for how often is the nut for holding a gear into place found on the floor, due to the fact that the gear, fitting the key (not necessarily loosely), had worked backward on the shaft, loosening the nut, which immediately ceased to function and

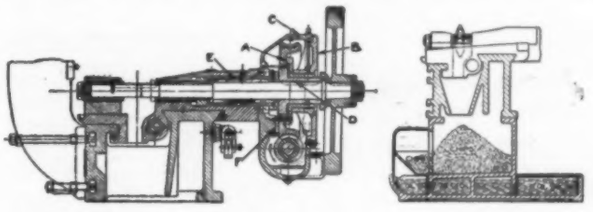

FIG. 17

dropped off, when the gear then proceeds to ruin the key, keyway, and then the shaft. This split washer, preventing the loosening of the nut as it does, keeps the gears rigidly fastened to the shaft. This method of holding the gears adds materially to the ease in changing. This method of holding is used on all the change gears where possible.

We would like to refer to the automatic feed change for double cutters, Fig. 19.

This is a mechanism which is adapted to later design Nos. 4, 5 and 6 machines for the following use:

When a large number of gears are to be cut it has been found advantageous to make both the roughing and finishing cuts at the same time by the double cutter method. This method is even used in some shops in the cutting of a single gear.

When cutting the first time through, both cutters must make their first cut through solid stock, which

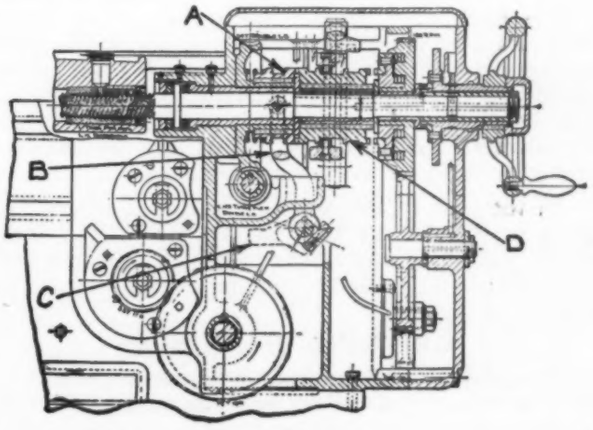

FIG. 18

necessitates a slow feed because of the finishing cutter and the greater amount of stock to be removed. To avoid the loss of time and trouble, which feeding by hand or changing the gears would cause, they have designed an automatic feed change mechanism which automatically changes from the slow feed, which is engaged for the first cut, to a feed twice as fast for the remaining cuts. This prevents willful and careless neglect. The feed is again slowed down, for making the first cut in the next blank, by means of a hand lever.

Another point is that every effort is made to keep the cutter driving train of gears tight by using splined shafts, clutched gears keyed, taper shafts, etc.

The index wheel, noted for accuracy, is first hobbed on a special index wheel hobbing machine, a very small amount of stock being left for finishing in position on the spindle and in the machine itself. After the wheel is mounted on the machine a hob is mounted

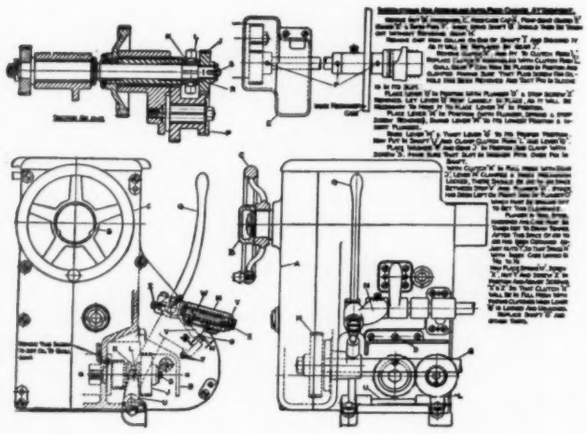

FIG. 19—*Automatic feed change for double cutters.*

in the position of the worm (the hob being a duplicate of the worm) and the wheel is cleaned out in position. After this is done the worm is put into place and lapped into the wheel. After this it is tested tooth by tooth with the worm in position. This is done with an indicating device which bears against the index wheel while the worm is indexed through one turn. If any errors appear, they are noted down on the wheel and particular care is taken to see that whatever permissible error is in the wheel is gradual and is distributed around the wheel. That is, the error allowed must be cumulative about the wheel and not from tooth to tooth. A chart is made of each wheel and the error noted thereon. The records appear as part of the inspector's report. The wheels are all carefully guarded from dirt and the chance of injury by being struck with any tool.

In the case of the hobbing machines where bevel gears are used, they have made them of the helical type of case-hardened steel and the index worm which is hardened and ground is in a horizontal position running in oil.

GRINDING MACHINES*

Probably one of the most important operations in the maintenance of rolling mill equipment is dressing of the rolls to keep their surfaces in condition to produce the quality of work required.

Rolls for different products vary in size and in the material from which they are made from the small hardened steel rolls in strip mills to the very large chilled iron rolls used for rolling heavy plate. These are made in sizes to handle the smallest and the largest rolls used in the industry. By means of forming attachments which can be applied to these roll grinding machines, rolls may be ground crowned, convex, concave or straight and the curves need not be the arc of a circle but may be any form required.

*Contributed by Norton Company.

Grinding as a method of dressing rolls is a very old practice, but up to the time of the modern roll grinding machine this practice was merely a "polishing operation" primarily because the machines employed were so light in construction as not to be capable of rapid production. Roll lathes were used to remove the bulk of the material necessary to true up the roll and not until recent years has the grinding machine been built rigid and powerful enough to do the work formerly done by the lathe and grinding or polishing machine combined.

On large rolls the modern grinding machine has many advantages over the roll lathe even where the finish is not required to be especially good. By the lathe method in order to get down under the worm roll face it is necessary to remove considerably more material to true up the roll than is necessary when employing the grinding method. The reason for this is that by passing across the roll several times and removing only a small amount from the diameter the moment the last bad spot has been cleaned up the operation can be stopped. Furthermore if the lathe tool by chance happens to dig in when a hard spot is found in the face of the roll the whole face must be turned down to the bottom of this torn place in the surface. By the grinding method owing to the very small chips removed by the surface of the grinding wheel these hard spots cannot be torn from the roll body or cause the wheel to dig in.

The quality of the rolls dressed by the grinding machine is also far superior to that produced by the lathe as the roll surface is smoother, and more nearly perfectly round and parallel.

In dressing rolls every thousandth of an inch that can be saved on the diameter increases the life of the roll. A roll may be worth several hundred or perhaps one or two thousand dollars and its value is mostly

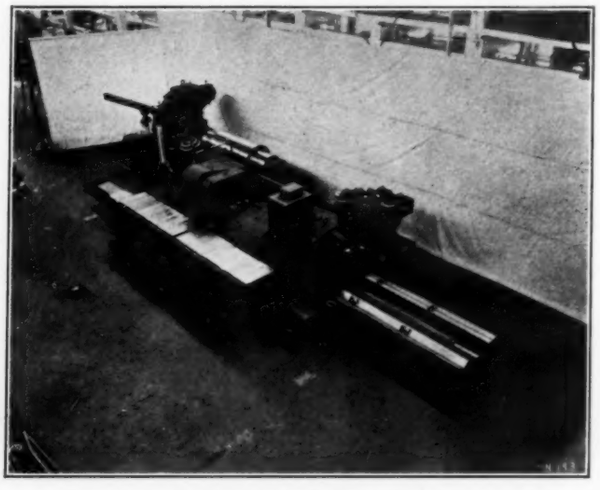

FIG. 20—*Roll grinding machine.*

in the inch or so of chilled surface. The life is the time of service before this chill has been exhausted, so even very small amounts saved on the diameter represent many dollars. Figures from a large plate mill tell us that the average saving per dressing by grinding over turning is 1/64 in. on the diameter and sometimes this figure is as high as ⅛ in.

(Continued on page 536)

Combustion Control

By E. G. BAILEY*

COMBUSTION control has been approached from so many different angles that it may be best to consider it basically and see just what factors we are dealing with and how best to correlate them to obtain the desired results.

The problem is basically the same no matter whether we burn coal on a stoker or in pulverized form, or whether we burn oil, gas or a mixture of fuels. We must supply fuel in proportion to the demand for steam and at the same time furnish the necessary air for the desired combustion efficiency.

To meet the varying demands for steam the rate of fuel and air supply must be changed from time to time. This calls for variable speed control of the fuel if fed in pulverized form or on mechanical stokers, also variable speed of the fans for forced and induced draft, or the use of valves or dampers for pressure control of gas, oil and air supply. It may seem like a simple problem to calibrate each of these controls and determine just what result or what capacity of each will be obtained and then determine the relationship of the position of one to the other. But the same quantities are not always delivered for the same position of a valve or damper, or the same speed of a stoker and fan, and very often the control system must be called upon to readjust the relationship between these different factors, not because the load has changed, but because the quantity delivered has not remained constant even though the position of the controlling device has remained unchanged. It is therefore necessary to find a control device that will regulate each of these moveable elements to bring about the correct final results in balancing the fuel supply in proportion to the demand for steam, and also obtain the proper relation between fuel and air, regardless of whether the change is due to total load of the station, the shifting of load from one boiler or group of boilers to another or the change in the supply of fuel and air due to numerous operating conditions.

The earlier forms of combustion control consisted of a damper regulator operated by steam pressure which supplied more or less air in proportion to the demand for steam, leaving it for the fireman to keep the fuel bed in the desired condition to utilize this air whenever and however it entered the furnace. As mechanical stokers replaced the hand fire and better oil and gas burners became available, the next step in regulation was to change the supply of fuel as well as the air.

Some systems changed the fuel and air simultaneously in presumably the right relation while others would increase the air supply by opening the damper and then the furnace draft would, in turn, increase the supply of fuel. The former system of direct connection between the fuel and air may be considered as a parallel system of control, while the other is a series or tandem system, but in neither case is there any definite assurance that the correct relation between fuel and air will always be maintained for best combustion efficiency, or that the fuel bed will be kept in the desired condition. This is really the crux of the problem and it is necessary to have a thorough understanding of exactly what the control characteristics are for the different ways of supplying fuel and air to boiler furnaces, and the limitations of accuracy to repeat the same quantities for different positions of control.

Fig. 1 shows the characteristics of the control equipment for a stoker-fired boiler with chimney draft carrying the gases away and the air supplied by forced draft. The forced draft fan is operated by a d.c. motor with 3 to 1 speed control having 14 points. The rate of supply of air from the fan motor alone would increase by steps as indicated. If the draft in the furnace was controlled by an uptake damper of the usual type it would have a characteristic similar to that shown, providing the damper was very tight so that it could be closed to an air supply of not over 10 per cent of the maximum. The rate of fuel supply is shown as being controlled by a variable speed transmission of the cone pulley type between a constant speed motor and the stoker with a 10 to 1 speed range. Assuming that all this equipment was designed so that at the maximum damper opening, maximum motor speed and the maximum stoker speed these would all be properly proportioned for best combustion efficiency, it is obvious that at no other rating would they be together unless the travel of the control was different in each case. In no case would the forced draft fan be slowed down sufficiently for as low a rating as could be obtained from the damper and the variable speed drive. This would necessitate a further control of a damper between the forced draft fan and the stoker.

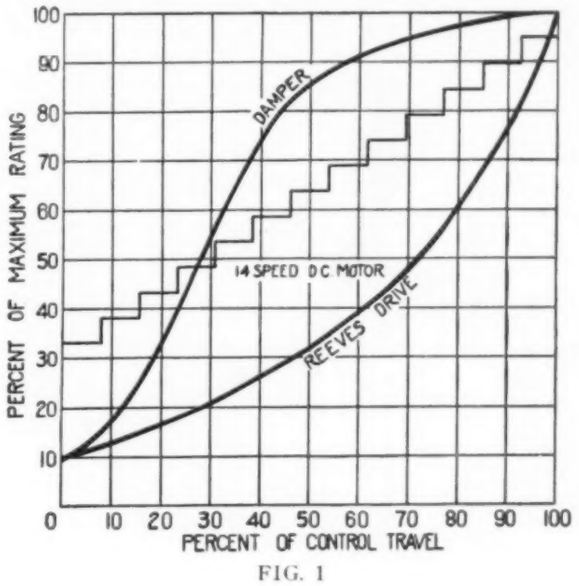

FIG. 1

If the boiler was to operate at 74 per cent of its maximum rating the forced draft fan motor would be on the ninth step, the induced draft damper should be 40 per cent open, which on a 90 deg. damper would be about 36 deg. open, and the variable speed drive

*President, Bailey Meter Company, Cleveland, Ohio.

control should be in a position of 89 per cent of its maximum travel. As none of the control lines run parallel from this point, either above or below, it is very difficult for these to be connected together on any parallel system of automatic control.

There is, in my opinion, only one correct way to regulate anything and that is to move the various controls the necessary amount in order to obtain certain definite results. Take for illustration the simple case of a water tank from which water is drawn for a variety of industrial purposes and it is desired to maintain a reasonably constant level of water in the tank. If this were to be accomplished on the parallel system of control it may be illustrated as having a meter measuring the discharge from the tank and another meter measuring the supply of water replacing it. It is obvious that if by either hand control or automatic control the two meters are always kept to read exactly the same and both meters are exactly alike, the water level will be maintained. However, this requires an accuracy of a millionth of one per cent, because any error or difference between the two would mean an accumulative result and the tank would either run empty or overflow.

Another similar illustration of parallel control would be to connect the discharge valve with an inlet valve of a tank so that when one opened the other would open and expect the amount drawn out would be exactly replaced and the water level maintained. It is obvious that this could not be accomplished, for no matter how accurately the valves were calibrated and checked against each other, the pressures will not remain near enough constant to assure equal flow through the two valves.

We will all readily agree that the only sensible way of replacing the water as it is drawn out is to use a float control valve which will maintain a constant level by controlling the water supply as determined by the water level itself, which is the one final result of accumulated difference between the inflow and outflow.

The control of one factor as illustrated above is comparatively simple, but where more than one factor is involved we often try to regulate two or more factors from one source of control, but the same basic reasoning holds, that we must select a final result which will act as a reliable guide for each individual factor to be controlled. This is analogous to solving for unknown quantities in algebra. We know we must have an equation for each unknown, also these equations must be true equations to represent the proper relationship between the various unknowns.

To illustrate this, Fig. 2 represents diagrammatically a steam boiler plant involving three controls for the combustion process; namely, fuel, forced draft and induced draft. To operate this plant satisfactorily these three basic controls must be guided by certain definite results. The first of these is steam pressure. Steam pressure is an indication of balanced relation

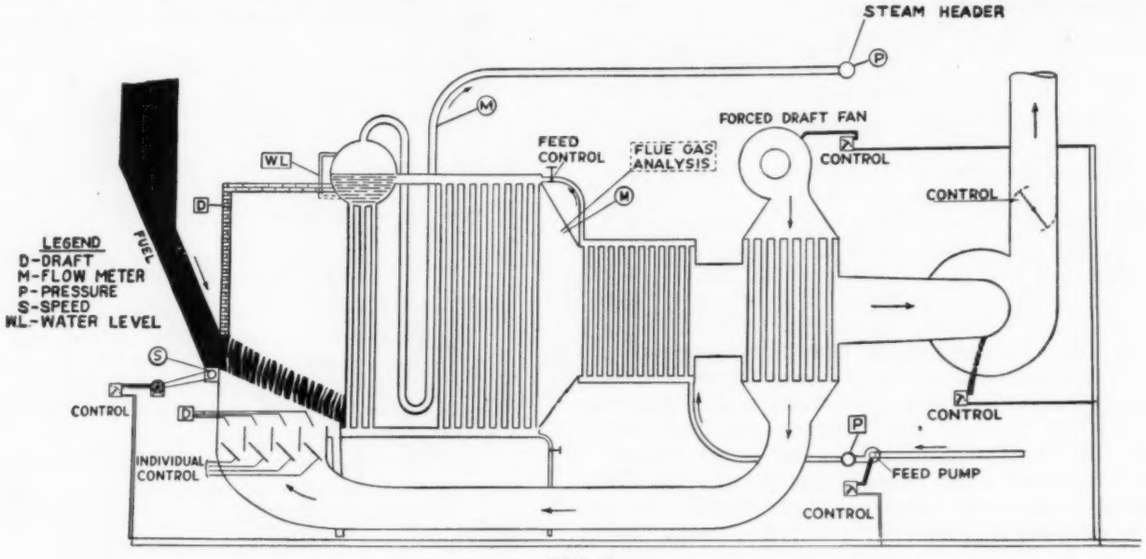

FIG. 2

between the inflow and outflow of Btu. from the boiler proper. When the steam pressure holds constant it indicates an exact balance. When the steam pressure is dropping it shows that the steam is carrying heat out of the boiler faster than the fuel is replenishing it; therefore the call for a higher rate of combustion. To supply this heat from coal or fuel in any form requires air, or in the case of a fuel bed if the coal is already on the grate, then the supply of air will be sufficient, but burning away of the coal calls for a replenishment of the fuel in order that the desired fuel bed conditions be maintained. A drop in steam pressure therefore calls for simultaneous increase of both the fuel and air supply. In the case of stokers with fuel beds the need for this exact synchronism of events is not so essential as it is in the case of pulverized fuel, gas and oil.

The second problem of control is the relationship between the fuel and air in order to maintain combustion efficiency. We know that the relationship between fan speed or damper position and air supply is not at all accurate. We also know that the relation between stoker speed, feeder speed, position of oil or gas valves does not hold a definite relation to the fuel supply. If these relationships did exist then every valve, every rheostat and every damper would be a meter and all we would need to do would be to record or note the position of same and we would know the quantity of fluid or material passing through

it. We must, therefore, search for a definite final result equivalent to the water level in the tank to guide us in controlling the available speed or quantity changing devices to obtain the desired relationship.

Experience has shown that the only feasible guide for combustion efficiency is to determine the percentage of excess air. The desired percentage of excess air for best combustion efficiency is that which will maintain the total losses due to excess air and unburned fuel at a minimum. Or, if the brick work is the essential factor, as it often is, one should maintain the lowest percentage of excess air and yet not encounter too great an expense in maintaining the brick work and furnace lining.

The steam flow — air flow relation is a positive, instantaneous and correct indication of the percentage of excess air and is well adapted as a guide for either hand or automatic control. The rate of steam generated is in reality the reading of a calorimeter showing the rate at which Btu. are developed in a furnace. The flow of air as indicated by the differential pressure across the boiler with proper precautions, is a measure of the rate of air supplied to develop the Btu. Fortunately the Btu. per pound of air used in combustion is substantially constant for all commercial fuels and the relation between steam flow and air flow is, in reality, a relation between the Btu. supplied to the furnace in the fuel and the air supplied to the furnace for burning same with the desired percentage of excess air.

The third factor for controlling this combustion process is found in the furnace draft pressure as being a balance between the induced draft and the forced draft. In other words, this is equivalent to the water level in a tank where it is desired to take the gases out from the furnace as fast as the air producing combustion is entering through the forced draft ducts. Balanced draft control is well known and has been used to great advantage for a number of years, but every one realizes its limitations as it controls only one thing, viz., the relation between outgoing gases and incoming air, and has completely ignored the all-essential factor of controlling the fuel supply to maintain steam pressure and also to vary the air supply in proportion to the fuel for best combustion efficiency.

The system of control which must be carried out for best results is the same whether it is done by hand or automatic means. This involves simultaneous changing of the rate of fuel and air supply to meet the demand for steam, and then readjusting the induced draft fan to obtain the desired percentage of excess air and also readjusting the forced draft fan to maintain the proper furnace draft. If the induced and forced draft have both been changed simultaneous with the fuel they need only be slightly readjusted, using the excess air and the furnace draft as guides in obtaining the correct final adjustment. A good fireman, with hand control, does identically this very thing and no system of automatic control will be successful unless it carries out the same procedure as a good man would do with good controllable equipment available for accomplishing any desired result called for as he observes the combustion and operating conditions.

There are some problems of control which come up in case of fuels burned in suspension which call for certain requirements to obtain best efficiency, as well as certain safety factors which are not required in stokers.

Take for instance a pulverized coal fired boiler with natural draft and damper control for air supply and a Reeves Drive controlling the speed of feeders for fuel supply. As seen from the curves of Fig. 1, it is impossible by any parallel travel to maintain the proper relationship between air and coal, as the air supply follows the relation as governed by the damper, while the coal feed follows a portion of the reciprocal curve of the Reeves Drive. There is furthermore an uncertainty as to just how much coal will be obtained for any given change in feeder speed and also how much the air may be increased for any given damper opening. The coal factor varies in most feeders with the amount of coal in the bin, the percentage of moisture, etc., while the air for any given damper position will depend upon how many other boilers are on the stack, weather conditions, etc. It is therefore obvious that in order to make a safe increase in boiler rating the air should be supplied faster than the fuel in order that any deviations from the desired combustion efficiency will tend toward an excess of air which is always safe from smoke or other difficulties, and later the air should be readjusted by hand or automatic means to suit the amount of fuel actually being fed to the furnace, as guided by excess air.

When decreasing the rate of steam output it is best to bring the air down more slowly than the fuel so as to again tend toward an excess of air, and later

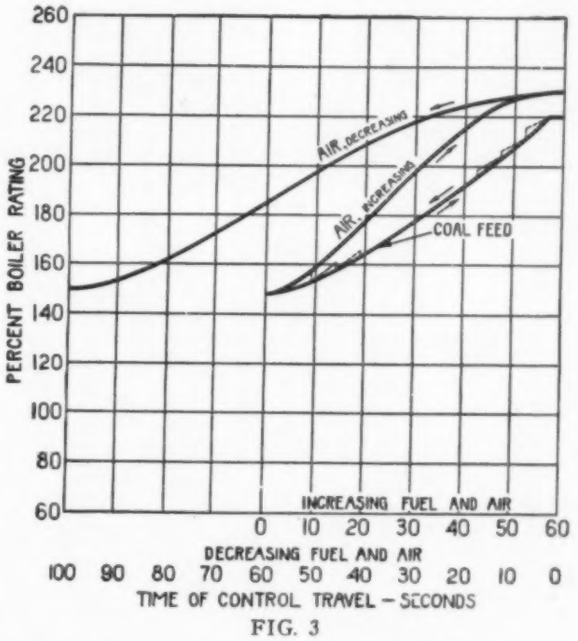

FIG. 3

readjust the air down to the exact amount of fuel as required for best combustion efficiency. A good fireman would naturally make these changes in inverse order, that is, when increasing the rating he would increase his air supply and then bring the fuel up. In decreasing the rating he would decrease the fuel supply and then bring the air down. To accomplish this with automatic control requires a different speed of the control of either the fuel or the air, or both, according to the direction in which it is going. Fig. 3 indicates what is to be accomplished by automatic control. If the control is made by steam pressure

alone, the air would go up faster than the fuel leaving it in excess. The air would come down slower than the fuel, again leaving it in excess, or working toward a high excess of air at all times. It should not be allowed to remain in this condition, however, and continuous readjustment toward the excess air would cause the actual increase and decrease of the air to very closely follow the fuel feed, but tending toward the upper side as shown by the small steps just above the coal feed curve.

It should be borne in mind that the increases in coal and air do not follow lines as shown in either Figs. 1 or 3, but they are bands of considerable width depending upon the variations of air and fuel supply for any given position of the damper or feeder speed changing device. It is not at all uncommon to find a variation of 30 or more per cent in the rate of pulverized coal discharge for a given feeder speed and under many conditions a variation in air flow of 20 or more per cent takes place with the same position of the damper, in the case of natural draft, and are less changed in the case of fans.

Another point of particular importance in the control of boiler equipment as shown in Fig. 2 is the feed water. It is obviously impossible to have the feed water controlled in proportion to the steam output without the net final result of water level in the boiler as the final controlling guide. In other words, the water level is the final guide as to whether the amount

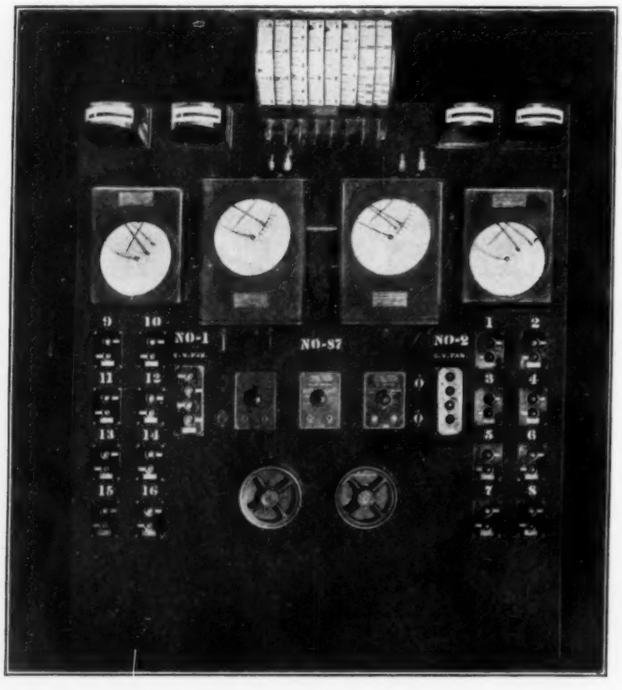

FIG. 4

of water leaving the boiler in steam, leakage or blow-off has been replaced from the feed line. The control of the feed valves may have to be changed from time to time even though the rate of steaming has not changed; such changes in feed valves being called for because of change in feed line pressure, or change in boiler pressure.

There is the same need for controlling all the combustion factors, such as fuel and air supply, from final results, the same as have been and always will control the feed water from the water level, thereby at one stroke correcting for all factors such as change of feed water pressure, steam pressure, leakage, blow-downs, as well as the rating. Any system of combustion control must be equally flexible in meeting the individual requirements which must be maintained.

Fig. 4 shows a metering equipment applied to a large pulverized coal fired boiler, part of which is used in the automatic system and the remainder is

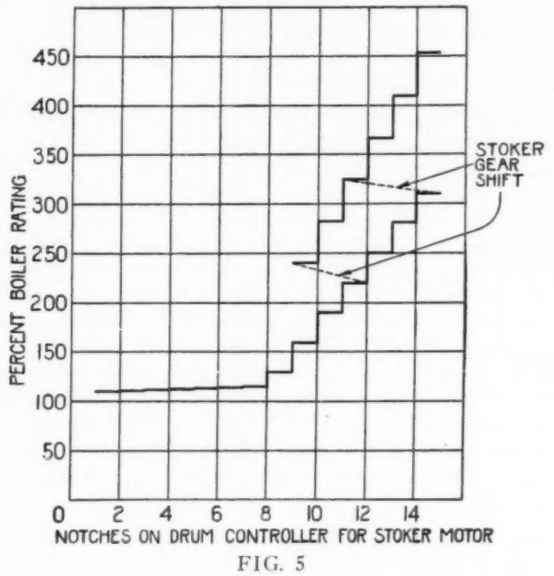

FIG. 5

indicating the operating conditions. The system of control there illustrated is operated by pilot motor mechanism of special construction and handles several boilers from one master control panel which can be either automatic or push button in case other than the standard pressure is desired, or if for any reason the operator wishes to meet any emergency. From this central panel the control, either automatic or push button, increases the fuel and air supply to each boiler simultaneously. The air supply is controlled by induced draft fan motors, together with dampers for bringing the rating down to less than that corresponding to the lowest fan speed. The fuel is controlled by rheostats on the d.c. motors operating each individual feeder. The air to the hollow wall ducts is controlled by spring balanced dampers so as to maintain the desired distribution of air at the different levels.

At the individual boiler panel as shown in Fig. 4, each of the feeder motors can be started or stopped and it is necessary to stop some of these motors for the lower ratings, as all feeders at the lower speeds will supply enough coal for about 120 per cent of boiler rating.

It is also possible to stop and start the two induced draft fans from this panel board, although they are normally stopped and started by the automatic control in conjunction with the damper position and the boiler rating required.

When bringing a boiler on the line or doing any unusual thing with it, the operator has push button control completely independent from the automatic. For instance, the central drum switch in No. 1 position enables the operator to supply more air by increasing the fan speed or opening the dampers according to

their position, covering both fans and dampers if they are both connected through from the individual drum switches to the central drum, or they can be controlled individually if desired. From the No. 2 position of the central drum switch the push buttons will then increase or decrease the supply of fuel. In No. 3 position the boiler is on base load conditions and the drum switches will increase both the fuel and air for each individual boiler alone and the air will be automatically and continuously readjusted to suit the fuel supply. No. 4 position is the same except that it carries through to the central panel where the steam pressure or the push button control at that point takes care of the capacity of this boiler, while the steam flow — air flow readjustment accomplishes the desired results in maintaining the proper combustion efficiency.

Many difficulties of automatic control have been laid at the door of the manufacturer of such equipment, while in reality it was the uncontrollable relationship between the factors that could not be properly obtained or maintained.

To a certain extent the firemen on hand control have been greatly handicapped due to the lack of proper relationship between the controller travel and the results obtained therefrom. For instance, Fig. 5 shows speed obtained from a d.c. motor on a stoker where a 14 point controller gave very little speed change in the first seven points, then beyond that each step was in reality too great for good results.

In one plant a 60 point rheostat was installed, yet only about 1/3 of the speed range of the pulverized coal feeders could be used within the limit of the air supply, which was the maximum obtainable from the stacks themselves. In another case the lowest feeder speed gave over 200 per cent of boiler rating and in similar conditions stokers are often found where the lowest speed obtainable would operate the boilers very nicely at 250 per cent rating, yet the fireman is called upon to operate the boilers on an average rating of 150 per cent, which can only be accomplished in such cases by stopping and starting the stokers.

The operator can obtain much better results in many cases if he is given good controllable motors and dampers over the desired range of operation, and furthermore if such control is brought to the meter board or at a convenient place in the boiler front where he can observe operating conditions while changing the controls and maintain them as desired instead of having it scattered all over the boiler room, or not within ready reach at all.

Automatic control is not justified in all existing boiler plants, but there seems to be no excuse why all control necessary for the fireman to operate should not be brought to a common point with the proper metering equipment to indicate his operating conditions and thereby enable him to accomplish the best results without useless physical effort.

Electric Furnace Installation†

By ROY S. SAWDEY*

THE development of the electric furnace for heat treating and carbonizing has been so rapid in the past few years that the writer thought a description of the electric furnaces installed at the Van Dorn Iron Works Company, Cleveland, Ohio, would be of interest.

The installation consists of four box type furnaces (Fig. 1) made by the George J. Hagan Company of Pittsburgh. The furnaces are double end, or a door at each end. This aids in the proper handling of material. The furnaces are of the metallic resistor type, with unmuffled heating elements mounted on the side walls. The temperature is controlled by means of an automatic control panel actuated by a Leeds & Northrup recording controlling instrument. With this equipment the temperature of the furnace chamber may be held to within plus or minus five degrees. The operating temperature of the heating elements is slightly above the furnace chamber temperature, thus insuring uniform temperature throughout the furnace chamber. The furnaces are insulated with a minimum of 10 in. of Sil-O-Cel and are enclosed in a steel shell, the plates being flanged for stiffness and reinforced with structural shapes. This construction eliminates the usual buckstays and gives a smooth outside surface.

†To be presented in connection with Electric Furnace Report, Wednesday, September 17, 1924.

*Electrical Superintendent, Van Dorn Iron Works, Cleveland, Ohio.

Furnace No. 1 (Fig. 2) was put in operation in January, 1922. The working dimensions of the heating chamber are 12 ft. long, 3 ft. 9 in. wide and 2 ft. high. The furnace has a connected load of 123 kw. for operation on 440 volts, 60 cycles, balanced three phase. The furnace was used for carbonizing, hardening and drawing. Therefore, the different cycles were interwoven, depending on the available work to be treated and the most economical sequence of the various operations.

The usual practice was to start the carbonizing operation after the furnace had been used for drawing at 900 deg. F. The charge for carbonizing consisted of steel bars and rods packed in boxes 11 ft. long, 12½ in. wide and 8 in. high. Each box with its charge weighed 750 lbs. The furnace charge consisted of two boxes, or a total weight of 1500 lbs. The charge was placed in the furnace when the furnace temperature was 900 deg. F. Charge and furnace was raised to 1680 deg. F. in 2 hrs. and 40 min. and soaked at 1680 deg. F. for 7½ hours. When operating in this manner the economy was 2.38 lbs. net per kwh. consumed. The steel rods were given a 3/32 in. case and it soon developed that due to the uniform temperature in the furnace chamber and the controlling of the temperature within close limits, the product was uniform, not only in each charge, but results were duplicated by following the same time and temperature cycle.

The furnace was also used for hardening and drawing automobile bumpers. The bumpers were 5 ft. long, 2¼ in. wide and ⅜ in. thick. The bumpers were charged in at each end and the total weight of charge was 1,000 lbs. With the furnace controlling at 1450 deg. F., 1,000 lbs. were charged into the furnace. Charge came to temperature in 90 minutes and the energy consumption was approximately 120 kwh.

When the production had increased so that another furnace was required, the operating cost of Furnace No. 1 was analyzed and it was decided to purchase another electric furnace. Furnace No. 2 was put in operation in December, 1922, and is an exact duplicate of Furnace No. 1, except the heating chamber width is 5 ft. 3 in. instead of 3 ft. 9 in. This permitted a heavier charge to be placed in the furnace, which naturally meant better economy as the No. 1 furnace did not operate at full capacity. Still further increases in production required additional furnace capacity. It became evident that best results would be obtained by separating the hardening and drawing of the bumpers from the carbonizing operations. Therefore, two shorter furnaces were purchased.

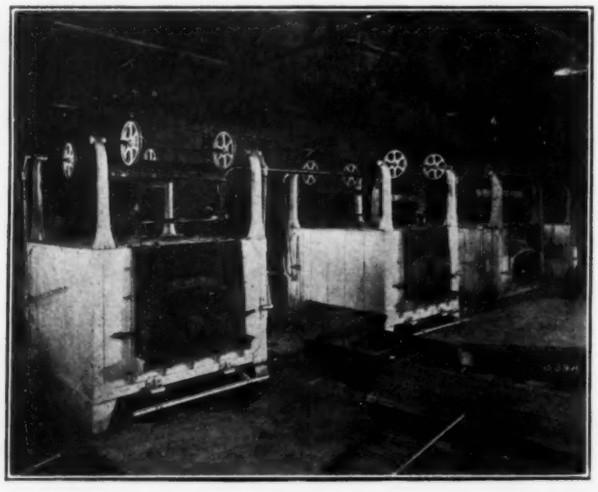

FIG. 1

Furnaces Nos. 3 and 4 (Fig. 3) were put in operation in July, 1923. These furnaces are of the same general design as Furnaces Nos. 1 and 2, except that they are smaller and were erected in the manufacturer's plant and shipped as a unit. The working dimensions of the heating chamber are 6 ft. 9 in. long, 3 ft. 9 in. wide and 2 ft. high. The furnace has a connected load of 65 kw. for operation on 110 volts, 60 cycles, balanced three phase. These furnaces were designed for the heat treating of automobile bumpers.

A very interesting development of the installation of the electric furnace was the elimination of the heavy cast carbonizing boxes. It was evident that if the weight of these boxes could be lowered the heating time could be shortened and the economy improved without affecting the quality of the work. The amount of scaling on the heavy pot was slight; therefore, a sheet metal box was tried. This meant more material could be carbonized in a given length of time because the heavy boxes were eliminated. Number 20 gauge sheet steel was used to form a box. The pieces were bent to shape from a straight sheet without notching. The bottom and sides are folded over to form a 3-ply end for the box. A cover of the same dimensions is made which fits tightly over the box. Suitable U clamps made of ⅞-inch hexagon bar placed over the top and sides hold the boxes in shape. The material to be carbonized is packed in the light

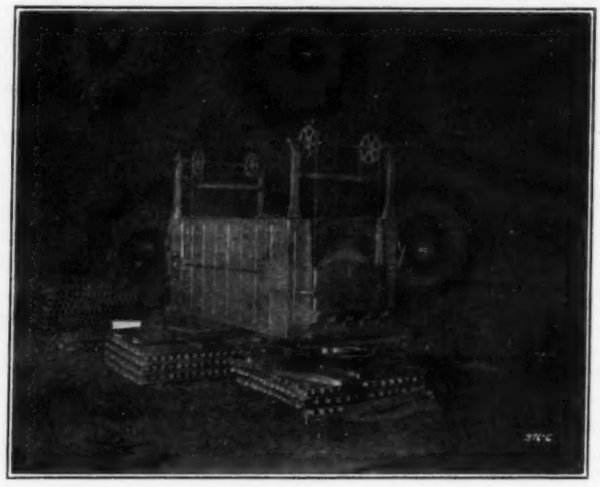

FIG. 2

gauge metal boxes on buggies which roll back and forth past the charging end of the furnaces. A six-inch by one-quarter inch plate with a large hole in the end of it is placed under the box before it is filled. This plate with the loaded box on it is drawn into the furnace by a 2-ton electric hoist, the haul line of which is attached to a chain which is pulled through the furnace and hooked into the hole in the ¼-inch plate under the box. All of the loaded boxes are pulled into the furnaces in this manner and likewise are pulled out onto buggies on the opposite end of the furnaces after being carbonized.

At present we have furnaces Nos. 2, 3 and 4 running night and day, seven days a week, on carbonizing, while furnace No. 1 runs night and day for six

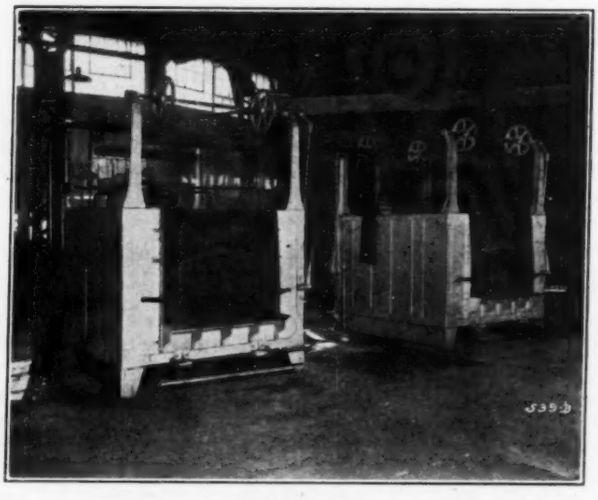

FIG. 3

days on hardening the material carbonized in the other furnaces. Furnace No. 1 also has a carbonizing charge for Saturday night, Sunday and Sunday night, or 45 carbonizing heats per week. This schedule insures the best economy as it leaves no time for the

furnaces to cool down and also eliminates any increase in the power demand for starting up the furnaces when the balance of the shop load is on.

The furnaces now operate on the following cycle:

The charge is drawn into the furnace when the temperature is approximately 1200 deg. F. and brought up to 1680 deg. F. in 1½ hours and maintained at temperature for 9 hours. The current is then cut off and the charge is left in the furnace for 1½ hours before it is withdrawn. After the charge is withdrawn and a new charge is pulled in the furnace is approximately 1200 deg. F.

After carbonizing, the material is allowed to cool in the boxes and is then unpacked and reheated to 1485 deg. F. in No. 1 furnace and then quenched. The economy for carbonizing is 3.6 lbs. per kwh. and for hardening 6 to 9 lbs. per kwh., depending on the class of material put through the furnace.

The addition of an electric furnace load of this type greatly aids in bringing up a low power-factor. A graphic power-factor meter was installed by the Municipal Light Division of the City of Cleveland, from whom power is purchased, which showed that the power-factor of the shop load of a few induction motors partly loaded at that time was .55 and when the furnace load was put on, the power-factor was raised to .95. (Fig. 4.) This shows that on services where the customer is given credit for a high power factor the electric furnace helps to make for lower power rates. The electric furnace makes a very desirable load for the central station, especially when operated 24 hours per day.

The repairs to an electric furnace are much less than on a coke, gas or oil fired furnace. The linings are not subjected to excessive temperatures and therefore last indefinitely. The labor charge per ton in the electric furnace is less than that of the coke furnace which was previously used. The time required to bring an electric furnace up to heat is considerably

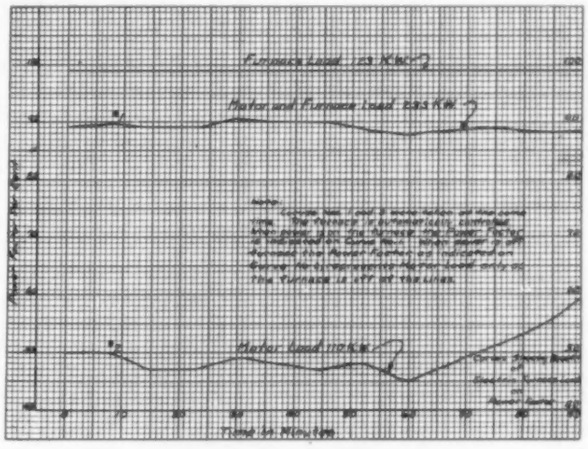

FIG. 4

less than that required for the coke furnace and the cost of current required is far less than the cost of coke.

The amount of rejections has been reduced to practically nothing as the temperature control instrument keeps the temperature within close limits.

Report of Electric Furnace Committee for 1924

By GEORGE H. SCHAEFFER,* Chairman

BEFORE starting the Report of the Electric Furnace Committee for 1924, we wish to take this opportunity to refer briefly to the reports of the previous committees. These reports, and we mean every one of them, have been of a high technical character, making them valuable both to the builder and the operator. The operating data has been collected from many sources, mostly from operating engineers, and the information thus secured has the added value which actual shop conditions are bound to impart.

These committees have worked hard; they have spent much time, but they have given us reports which will be used as references by many of our members. Particular mention is due Mr. E. T. Moore for his exceptional activity.

The question as to the effect in the steel of nitrogen generated by the electric arc in the furnace while melting down at a high voltage has been an open one. In reviewing the problem, we find that in the crucible, open hearth, Bessemer or electric furnace process, there is ever present the nitrogen content in the atmosphere, and in all these processes, there is at least an equal opportunity for chemical combination. From all our available information we feel confident that within the limits of melting now used commercially, for example, up to 210 volts, the electric arc does not cause a chemical combination of nitrogen with the steel bath, and therefore does not cause any deleterious effect from nitrogen fixation. We are further supported in this contention by the following information furnished by the Department of Commerce, Bureau of Standards, which shows that nitrogen occurs in an equal or less degree in electric steel than in open hearth or Bessemer. The following is the quotation:

> "Electric steels normally contain from .002 to .005 per cent nitrogen.
>
> "Open hearth steels contain nitrogen in the same range—while Bessemer steels normally carry from .010 to .015 per cent nitrogen."

Serious consideration is now being given to the use of high frequency induction furnaces on a compara-

*Electrical Engineer, Carpenter Steel Co., Reading, Pa.

Other committee members include: E. A. Hurme, Engineer, Steel Mill Division, Westinghouse Electric Company; John A. Seede, Industrial Engineer, General Electric Company; C. F. Cone, Sales Engineer, George J. Hagan Company; E. D. Sibley, Plant Superintendent, Metropolitan Edison Company; Horace Drever, Sales Engineer, Electric Furnace Construction Company.

tively large scale for the production of high grade alloys for special purposes and for refining precious metals, although there have been no commercial installations. The chief advantage of the induction furnace for this class of work lies in the fact that contamination of the product can be prevented by controlling the atmosphere in which it is melted. Other applications of the high frequency induction method of melting remain to be developed.

There are two possible methods of obtaining the high frequency used in this type of furnace. The system using a spark discharge from static condensers for generating the high frequency is limited to 20 kva., single phase, or 60 kva. capacity, 3 phase. This limit is imposed by the spark gap. The limit of capacity of the method using a high frequency generator has not as yet been determined.

Inasmuch as the previous reports dealt mostly on the electric melting and this particular field had been covered in such a comprehensive manner, the board of directors asked that we devote most of our time to the "medium and low temperature equipment." With this idea in view, we have accordingly limited the subject matter relating to electric melting furnaces to detailing the improvements to furnaces; furnace control, and furnace operation that have taken place since the last electric furnace report.

Mr. John A. Seede, industrial engineer of The General Electric Company, Schenectady, is well qualified in this particular line, having taken an active part in the development since the introduction of the electric arc furnace. He will deliver a paper covering this particular section of the report.

When we are made acquainted with these improvements, by means of which we can speed up the furnace and increase its tonnage or reduce operating costs, we will surely consider the advisability of applying them to the furnaces installed several years ago.

The field of the "medium and low" temperature equipment is greater by far than the high temperature arc melting furnaces. The applications of this equipment cover a much wider range of product and for this reason we find the equipment installed in greatly diversified industries. We are exceptionally fortunate in having Mr. E. A. Hurme, engineer of Westinghouse Electric, Pittsburgh, and Mr. C. F. Cone, sales engineer of the Hagan Electric Furnace Corporation, make a detailed report on this type of equipment. Both these men are exceptionally well qualified for this by their actual experience covering a number of years in this particular field.

Much has been said about power consuming equipment. It might not be amiss to consider briefly whence the power to supply this ever increasing demand comes from; also whether the load is a desirable one from the power end; and, again, whether in the near future heating load will assume as great or greater importance than the motor load. In short, we are seeking the central stations' point of view as regards the future heating load. Mr. E. D. Sibley, electrical engineer for the Metropolitan Edison Company, is well qualified by his actual central station experience and his close association with his progressive company, to handle this phase of the report.

Before starting I want to ask a favor of every one present; that favor is, "Help make this report more valuable by adding to the discussion."

If there is anything said that does not meet your approval from your particular angle, let us know it, and tell us why.

If there is anything said that does meet your approval, tell us.

If there is anything omitted, tell us.

Electric Melting Furnaces

By J. A. SEEDE*

IN studying the progress made in the application of electric furnaces in the iron and steel industry, two lines of development may be considered in decreasing the cost of production. That any change in electric furnace practice is worth our consideration is indicated by the 1923 electric furnace production of steel castings, totaling 235,958 tons, or 50 per cent more than the best previous year, 1920, and the electric furnace production of alloy steel castings amounting to 29,054 tons, or 64 per cent higher than the best previous year, 1922. This increase indicates the growing importance of the arc furnace in the production of iron and steel in this country, and in considering this increase, the means being used to bring about greater production and lower costs take on more interest and importance.

These lines of development may be considered in the order of their importance as follows:

First—Refinements in furnace design, accessories and operation.

Second—Increasing productive capacity of furnace.

Refinements in furnace design, accessories and operation usually result in small percentage increases in output, the principal benefit coming from reduction of one or more important items, such as electrodes, linings, etc.

Along this line, the most recent changes have been in using so-called electrode economizers and the Soderberg electrode.

The former is a device that fits closely about the electrode where it emerges from the roof, keeping the air from the hot electrode and cooling it without oxidation. This results in unchanged cross section, enabling the roof joint to be kept tight, which prevents escape of hot gases. The unchanged section also prevents increase of electrode resistance, thus decreasing power losses.

The Soderberg or self baking electrode will undoubtedly continue to be a source of discussion for some time to come. To the average operator, accustomed to a carbon or graphite electrode ready for use

*Electrical Engineer, General Electric Company, Schenectady, N. Y.

as received from the manufacturer, there is a natural hesitation in considering an accessory that requires extra auxiliary apparatus and operations. On the other hand, we must not blind ourselves to the fact that the Soderberg electrodes have already become firmly established in smelting furnaces, making calcium carbide, ferro alloys, etc., but are also being successfully used in steel melting furnaces.

The advantages claimed for these electrodes are:

1—Reduced cost per pound.

2—No devices necessary to protect against corrosion.

3—Reduced electrode consumption.

4—Reduced delays due to electrode troubles.

5—Independence of electrode manufacturers or transportation.

6—No reasonable limit to size and shape.

In bulletin sent by Electric Furnace Construction Company this saving is given as 50 per cent over the non-threaded type, which would probably mean a corresponding saving over the threaded type of about 35 per cent. It is assumed that the figures given include all cost items, such as iron casing, welding operations, calcining and grinding of raw materials, royalties, etc., and if so, the saving is certainly worth while. The other factors are also very much worth while and tend to more than balance the additional apparatus, operations and difference in practice. By the latter I refer to the objection raised by one prospect who did not want to take out the hot stub and let it cool in a sand box while waiting to add another section.

Increasing Productive Capacity of Furnace.

The productive capacity of a furnace unit may be increased, shortening the time to produce a heat and decreasing the time between heats. To shorten the time of producing a heat means increasing the energy input to the charge, which, with a straight electric furnace equipment, means either increasing the transformer capacity or otherwise changing the electrical characteristics so that the metal will be melted with the least possible delay.

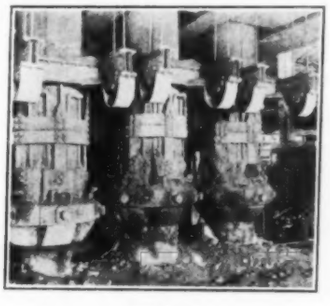

FIG. 1

Any method of decreasing the demand on the power supply, such as increasing the energy content of the charge by preheating will shorten the time the metal is in the furnace and increase its production.

Pre-Heating Charge.

It is well known that electric heating is used to best advantage when preliminary heating has been done with cheaper sources of heat, but it is doubtful if the all possible advantages have been realized. Several years ago, Mr. E. T. Moore pointed out at one of these meetings that no advantage is to be gained by melting and partly refining steel in comparatively small quantities for completion in the electric furnace, the melting in the open hearth furnace and transferring to the electric furnace costing more than straight melting in the electric furnace. There is also the added possibility of contamination from the fuel and a method of substituting cheaper heat without these disadvantages is correspondingly interesting. I refer to the preheating by oil or gas in the combined charging bucket and preheater as brought out by Mr. L. C. Loshbough, Chicago, Ill., (Fig. 2), in combination with the use of an opening roof furnace. The preheater is placed in a pit, the top being level with the foundry floor line and the scrap charged in any convenient way, such as by wheelbarrows. After filling the bucket, the charge is brought up to approximately 900 deg. C., and as soon as the previous heat has been taken away, the furnace top is swung clear and the red hot charge dropped into the furnace with a delay of about 5 minutes between heats. That such a method is profitable is indicated by the energy consumption dropping in several installations from approximately 600 kwh. per ton to less than 400 kwh; this amount of electrical energy, 200 kwh., being replaced by not more than four gallons of oil. The advantages of the preheating process may be summarized as follows:

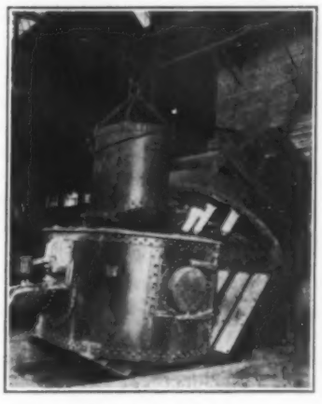

FIG. 2

Time of melting is reduced 30 to 40 per cent.

Power and electrode consumption is reduced in the same ratio.

No contamination of the charge as the metal is not fused.

Electrode breakage and difficulties in starting are reduced on account of ease of maintaining arc on the hot metal.

Higher melting speed is obtained through higher average power input on account of smaller current surges.

The number of heats are increased, which reduces overtime labor and increases profits with the same or greater tonnage output.

No increase in labor as the scrap is handled once only, from the scrap pile to the wheelbarrow.

Electrical Equipment.

The need for increased production has led to a gradual increase in the input to arc furnaces from an original capacity of 225 kva. for a one-ton furnace in 1910 to 600 kva. and higher at the present time.

With the original equipment, it was a comparatively simple matter to obtain fair operation with one secondary voltage, usually a compromise giving about 60 volts across the arc, but with the increased capacities, a higher voltage for melting and a lower voltage for refining seemed to offer advantages. As two-voltage operation increased, the question arose concerning heat absorption of the metal and danger of burning through too high power input, and this question is not yet definitely settled. At the present time, some furnaces making high class ingot steels are being operated at one voltage, while practically all new equipments for steel castings are using two voltages. In view of the fact that it is a simple matter to obtain small or large differences in voltage ratios, it appears that a large voltage range, such as 90/150 volts, can be used to advantage for steel castings, and a smaller ratio, such as 90/120 volts, for ingot steel.

The voltage range will have some effect on the arrangement of the high voltage transformer windings—with small voltage ratios or where Y delta switching is not permissible, the high voltage windings being Y connected and where Y delta switching can be used, the high voltage windings are delta connected.

A number of other questions have been argued, such as reactance in and external to the transformer, and the result is a transformer with approximately 10 per cent inherent reactance with 10 per cent to 20 per cent external reactance, either air core or iron core, arranged to be cut in during melting the cut out during refining or standby.

Electrode Regulator.

Although this part of the electrical equipment has been well standardized and seldom is the cause of any delay despite the demands made upon it, and they are more exacting than any other part of the electrical equipment, some recent changes in the General Electric regulator may be of interest.

In passing, a comment on the reliability of this type of regulator might not be out of place. One of the old type regulators was installed with a Heroult furnace at the plant of the Millbury Steel Company, Millbury, Mass., in 1918, and recently we were asked to inspect the regulator, which had operated for six years without any attention. All that was required to put the regulator in first class condition was a few contactor tips, tightening a few connections, etc., which may justly be considered a creditable showing.

As will be seen from Fig. 3, the panel has been considerably simplified, principally in the contactors and relays on the top section, and elimination of open lever switches and other live parts on the front of the lower section.

As now arranged, there are no exposed live parts on the bottom and middle sections, the lowest being the high speed contactors, which are more than five feet from the floor.

As will be seen from the diagram (Fig. 3), mechanical interlocks and separate contactors for dynamic braking have been eliminated by using the S. P. S. T. contactors, which make the connections for raising and lowering the electrodes with the upper contacts and dynamically brake the electrode motors with the lower contacts in a very simple way.

The shunt relays, formerly used to render the electrode down feed inoperative in case of power failure, have been replaced by a floating type relay which meets an additional condition. This relay is connected across the arc and is adjusted so that when the arc voltage drops below 25 volts the relay will open the electrode down feed circuit and when the arc voltage increases to 30 volts it will close that circuit. This feature makes the contact of electrode and metal almost impossible, and thereby saves time that might otherwise be lost in correcting carbon contamination by electrodes.

The double throw switch on the operator's panel for changing from hand to automatic has been elimi-

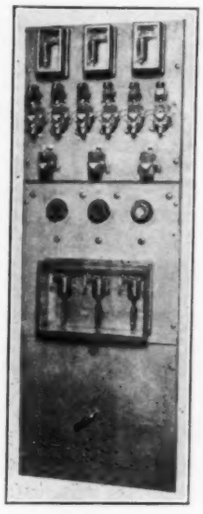

FIG. 3

FIG. 4

nated by a small switch built into each push button station. This is shown on right hand side, Fig. 4, lower section of the single electrode control panel, such a panel being used to control single phase furnaces for melting or smelting, the complete equipment being very compact and accessible. This has resulted in an operator's panel so small that it can be mounted on the primary panel or in any other convenient manner.

Reducing Time Between Heats.

This is obviously a mechanical problem, that is, to get the melted metal into the ladle and charge the furnace with the minimum possible delay. Three solutions have been offered for this problem, as follows:

Charging Machine.

Similar to the well known method of charging open hearth furnaces, charging machines have been proposed for use in electric furnaces and several arc furnaces are being operated successfully in this way, and where the operator lifts the electrodes high enough to avoid breakage and otherwise uses this device with reasonable care, the results have been profitable.

Opening Roof.

The opening roof feature referred to above under the subject, "Preheating," appears to offer the simplest way of charging a furnace, that is, simply dropping the charge into the furnace from a charging bucket, as shown in Fig. 2. The principal objections raised to this method of operation are adverse effect

on the incandescent roof, lining and electrodes exposed to the free air, but this has not been found excessive in practice, as demonstrated by 500 heats per roof and normal electrode consumption.

Multiple Melting Furnace.

An ingenious method of decreasing the time between heats is the use of one set of electrodes, transformer, and control panels, with two furnace shells mounted on a turntable, as recently installed by Wm. Swindell & Brothers at the plant of Kelly & Jones. As shown in Fig. 5, this makes a compact arrangement and operated with lack of complication that might be expected with the necessity of accurately placing the furnace beneath the electrodes after each heat. To anyone accustomed to ordinary wattmeter charts with 20 to 30 minute intervals between heats, that is, power off to power on, Fig. 6 is somewhat startling, 4-minute intervals being common and shorter intervals happening frequently, the record being 2 min. 8 sec. This results in greatly increased production, from 6 heats to 9 heats, and much better load factor.

In this system, the electrical equipment is producing 95 per cent of the average cycle or on a monthly

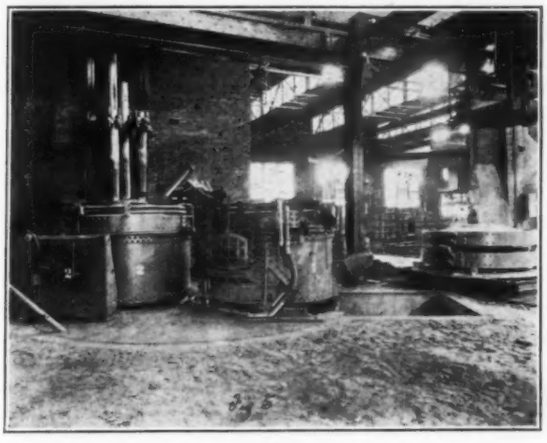

FIG. 5

basis, 4 weeks, 24 hours per day, 43 hours down at end of week, the multiple unit has a load factor of over 70 per cent when a single furnace would have load factor of 45 per cent.

With many up-to-date power companies, this would mean a considerable reduction in power cost, a typical example showing in the capacity and load factors cited, a saving in base price of nearly 30 per cent.

As in the case of the opening top furnace, it might be expected that the incandescent electrodes in contact with free air would show greatly increased consumption, but the contrary is the case, the outer skin of the electrodes cooling rapidly and protecting the hot interior from oxidation. As each furnace shell is idle one-half of the time, plenty of time is available for making bottom and otherwise keeping the equipment in A-1 condition. After the furnace is charged, there is plenty of time for the lining to preheat the charge and by the time the off shell is placed beneath the electrodes the charge has been raised to a point where it is much more easily melted than ordinary cold scrap. If desired, additional heat can be put in charge by means of oil or gas heating during the off period.

It is recognized that the roof and sidewalls must be replaced or repaired every 75 to 300 heats, depending on circumstances. With the multiple hearth system, one furnace should always be available, and if it is desired to maintain full output at all times, an extra shell insures such productive capacity at a small extra cost.

While it is obvious that the first heat after a furnace has been standing idle, especially after relining,

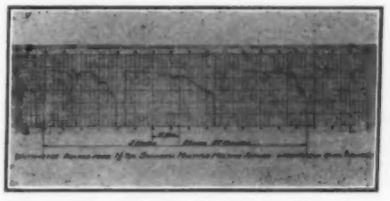

FIG. 6

takes more power than subsequent heats, careful measurements have been lacking and we are indebted to Mr. J. D. Haynsworth, Public Service Company of Northern Illinois, for the following figures on 3-phase arc furnaces of 3 and 6 tons capacity for melting steel.

The average of 22 heats on all three furnaces was as follows:

First heat	839 kwh.
Second heat	720 kwh.
Third heat	609 kwh.

The average decrease from the first to second heat is 119 kwh., or 14 per cent, and from the second to the third 111 kwh., or 15 per cent. These figures include some unusual variations, such as two heats of 452 and 501 kwh. per ton, respectively, in the 6-ton furnace; two of 436 and 473 kwh. per ton in one of the 3-ton furnaces; one of 1,008 kwh. per ton in the 6-ton fur-

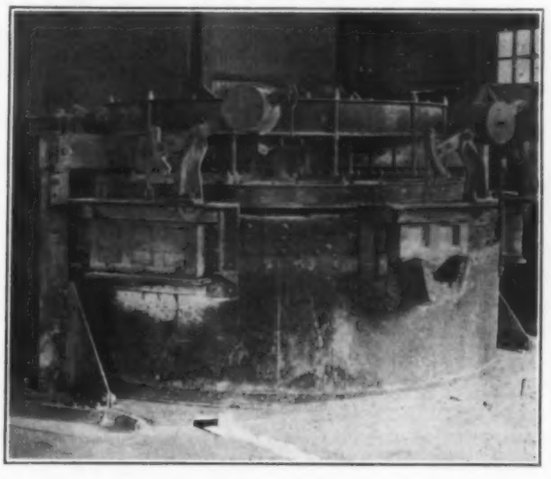

FIG. 7

nace starting Monday morning, and one of 1,445 kwh. in one of the 3-ton furnaces after it had been relined.

Induction Furnace.

In view of the general interest in electric furnace developments, a brief reference to the largest induction furnace now operating in this country may be of value.

For several years the 2-ton furnace (Fig. 7) has been operating at the Pittsfield works of the General

Electric Company with entire success, light alloy steel scrap being melted economically and highest quality ingots produced.

The linings, formerly a nightmare in this type of furnace, now average 500 heats, and individual linings occasionally go 30 per cent above this figure.

As a result of this successful operation, a 6-ton furnace (Fig. 8) at the plant of the Allegheny Steel Company, Brackenridge, Pa., where successful operation has been obtained ever since the furnace started late in 1923.

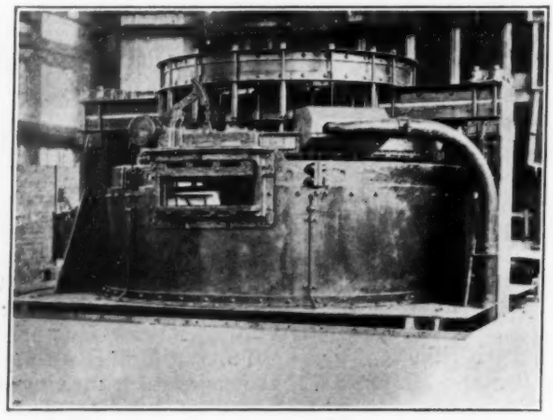

FIG. 8

The furnace is comparatively small, having a total height of 24 ft., 14 ft. being below floor level, and floor space 28x27 ft., all dimensions including tilting apparatus and maximum space required for tilting.

The power supply is 25,000 volts, 3 phase, 60 cycles, and is stepped down through a 1425-kva. transformer bank to 2200 volts for the synchronous motor generator set, which changes the 3-phase, 60-cycle power to single phase, 85 cycles at 2200 volts.

The synchronous motor is designed for 80 per cent leading power factor operation and is controlled by an automatic power factor regulator so that load may be taken at best power factor.

The generator has a normal rating of 2,000 kva., which allows a margin for emergencies over the normal demand of 800 kw. at 50 per cent power factor.

When used as a melting furnace about 4 hours are required to produce two ingots of 3,500 lbs. each with an average overall energy consumption measured at the 25,000-volt lines of about 800 kwh. per ton. As in all furnace work, occasional heats run considerably lower than this figure and better average results will come with longer experience, although the quality and uniformity of the product at present leave little to be desired.

From these developments and similar activities in melting and heat treatment of other metals and alloys, it becomes more and more evident that the electric furnace is assuming its proper position as a factor of great industrial importance. In view of the economies effected, convenience and precision of operation and comparative quality of product, such progress is inevitable.

Medium Temperature Furnace Installations

By C. F. CONE*

THIS company† had plants operating in New England and near Chicago. They decided to erect a new plant in Buffalo, and they felt that the installation of an electric furnace for the annealing of their wire would eliminate many of their troubles in the manufacture of horse-shoe nails. The annealing furnaces at the other plants were coke and gas fuel and they were unable to obtain a uniform anneal, causing a large percentage of rejections.

The furnace purchased is known as the regenerative car type furnace. There are three chambers—heating, cooling and pre-heating. (Fig. 1.) The cooling chamber is in tandem with the heating chamber with a common door between. The preheating chamber is located at side of cooling chamber with the common wall removed to allow free interchange of heat from the hot to cold charge. The whole is insulated with 10 in. of insulating material and encased in a steel shell. After the cycle has started, the operation is as follows: The car in cooling chamber is removed. The car in heating chamber is moved into cooling chamber. The car in preheating chamber is placed in heating chamber and a cold charge is placed in the preheating chamber. The cars are moved by means of endless chains, installed below the floor level. The chains are provided with dogs, spaced at car length, which engage lock bar pins in the furnace cars. The doors are operated by air hoists. The control levers of the conveyor chain and air valves for doors are located on a control pulpit. From this point operator can raise and lower all doors and move cars in and out at will.

The charge is ⅜-in. diameter wire delivered in coils weighing approximately 250 lbs. per coil. The coils are stacked on spiders and the charge per car is approximately 7,500 lbs. (Fig. 2.) The charge is loaded and unloaded from cars by means of an electric hoist. The charge remains in each chamber three hours so that the furnace delivers 3½ tons every three hours. The heating chamber temperature is held at 1360 deg. F.

The heating chamber is 12 ft. long, 7 ft. wide and 4 ft. high. The heating elements consist of nickel chromium ribbon, suspended on the side walls by means of special refractory insulators. The heating units are located in the heating chamber only. The

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total connected load is 180 kw. for direct connection to 440 volt, 3 phase, 25 cycles.

The temperature of the heating chamber is automatically controlled by means of a potentiometer type of recording controller. The controller operates an automatic control panel, which throws the heating units on and off the line. A typical control panel is shown in Fig. 3. It consists of a motor operated

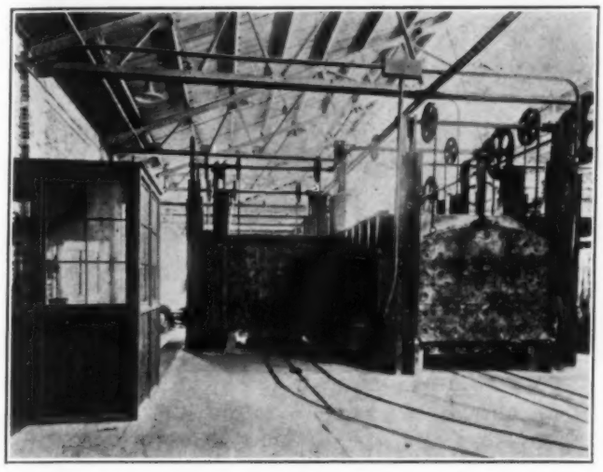


FIG. 1

switch, actuated by the control instrument. When the temperature of furnace increases or decreases from the setting of the instrument, contacts in back of instrument close and complete the circuit of the motor operated switch. The switch in revolving opens or closes the main line contactor. When heavy contactors are used, an auxiliary contactor is installed between the motor-operated switch and the main contactor. Overload relays or fuses are mounted on the panel.

This furnace has been operating practically every working day since November, 1920, and has turned out several thousand tons of annealed wire, without a single rejection or reheating. All the inherent troubles of the fuel furnaces have been eliminated. Normally the furnace operates 10 hours per day and an economy of 185 kwh. per ton is obtained. During peak production it operates 24 hours per day and an economy of 115 kwh. per ton is obtained. This latter figure gives practically 100 per cent thermal efficiency, or in other words, the cold charge recovers from the cooling charge the equivalent of the radiation losses.

A large saving has been made in the labor necessary to operate the equipment. No attendance is required for the furnace, as it is automatic. The labor charge against the whole operation is represented by the time of two men for a seven-minute period every three hours. They operate the mechanical equipment for moving the furnace cars and doors and also to load and unload the furnace. The power cost in Buffalo is based on horsepower connected load per year, and in normal times will have a low value per kwh. consumed.

The plant management states that the cost per kwh. does not materially affect the unit cost of his product and that he would still use the electric furnace were his cost 3 cents per kwh.

The maintenance on the furnace is practically nothing. The actual figures are $25.00 since the furnace was installed nearly four years ago.

Gray & Davis, Inc., Amsbury, Mass.

This company does deep drawing of one-quarter and five-sixteenths stock. They draw from flat to 7½ inches deep in four operations and require two anneals. A pusher type oil furnace was formerly used. The material was placed in pans and pushed through the heating chamber and allowed to cool in air. A large number of rejections were obtained, due to nonuniformity of temperature and poor temperature control. Pickling costs were high and die life short, due to excessive scale. Therefore, they installed an electric furnace to replace the oil fired equipment.

The furnace is of the counter-flow regenerative car type (Fig. 4) and has six chambers with two rows of cars moving in opposite directions. At each end of the furnace is located a preheating and cooling chamber with the common wall removed; thus permitting the transfer of heat from hot to cold charge. The two heating chambers are located in the center with a common firebrick wall. Doors separate the heating from the cooling and preheating chamber. There are three furnace cars on each side, or a total of six cars in the furnace. The cars are moved in and out of the furnace by means of an air cylinder, chain and sheaves. At each end of the furnace is a pitless type transfer car, which permits the cars to be moved readily to the loading and unloading track, located at each side of the furnace. The cars are provided with alloy car tops which raise the charge approximately 5 in. above the tile, thus insuring uniform and rapid heating.

The heating elements consist of heavy nickel chromium ribbon, suspended from the side walls on special refractory hangers. Each heating chamber is 7 ft. 6 in. long and 4 ft. wide. The car top is 6 ft. 6 in. long and 2 ft. 8 in. wide. Each chamber has a connected load of 110 kw. for operation on 220 volts, 3 phase, 60 cycles. Each chamber is controlled automatically by means of a potentiometer type recording controller,

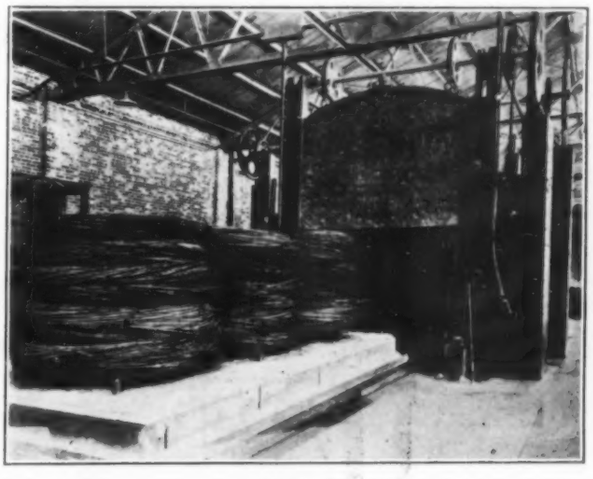


FIG. 2

actuating an automatic control panel. This also limits the power consumed to that actually required by the charge.

The furnace operates at 1450 deg. F. and will handle a production of 2,500 lbs. per hour. Each car is charged with 625 lbs. of work and remains in each chamber 30 minutes. The furnace will deliver two cars every 30 minutes, or four cars per hour. When

operating on 24-hour cycle the economy is 145 kwh. per ton annealed.

The furnace has been operating less than a year, so that accurate figures on saving cannot be obtained. However, only a slight scale is evident on the work and it can be readily removed, thus reducing the pickling cost. After the scale is removed the surface is smooth and not pitted as was the material annealed in the oil-fired furnace. This has a material effect on the die life as the smooth surface of the polished die does not become scratched. The pieces are uniformly heated and when further operations are performed the material "flows" evenly and does not "tear" as is the case when hard and soft spots are obtained.

Canadian Allis Chalmers, Toronto, Canada.

This company desired a furnace to anneal transformer laminations, and after an investigation felt that the electric furnace would give them a lower unit cost than a fuel fired furnace. They desired to eliminate the usual heavy cover or box on the annealing car, thus saving heat and high maintenance of covers.

The furnace purchased was the double end car type. The furnace has a door at each end and the doors are motor-operated. (Fig. 5.) At each end of the furnace is located a pitless type transfer car to readily move the car to the loading and unloading track at side of furnace.

The heating elements are nickel chromium ribbon suspended from side walls on special refractory hangers. The total connected load is 210 kw. for operation on 440-volt, 3 phase, 25 cycle. The furnace is 12 ft. 9 in. long and 5 ft. 4 in. wide. The furnace is insulated with 10-in. insulating material and enclosed in a steel shell.

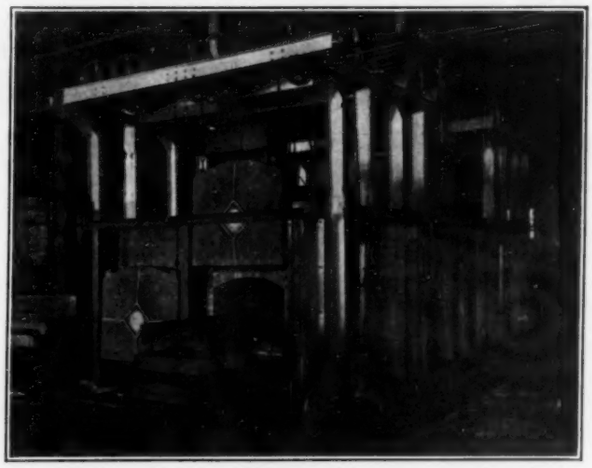


FIG. 4

The charge consists of a stack of sheets. The maximum charge is eight tons and the average charge is 6 2/3 tons. In order to take advantage of the low off peak rate, the heat is only applied at night. The power is put on at 6 o'clock and charge comes to temperature and soaks all night. The operating temperature is 1600 deg. F. In the morning the hot car is removed and cold charge placed in the furnace. Power is cut off, but cold car remains in furnace all day with doors closed. Operating in this manner, the economy is 340 kwh. per net tons annealed.

While it was believed that the heavy covers could be eliminated, they were purchased with the equipment and used as cooling hoods. The stack in the furnace is covered with light scrap sheet metal, which greatly reduces the weight and makes a considerable saving in power. If the furnace was in continuous operation for 24 hours a day, this would mean a considerable saving as in addition the heating and soaking time of the charge would be reduced. The stack of sheets have a uniform temperature throughout; the edges are not overheated and the scaling is slight.

Nash Motors Co., Kenosha and Wilwaukee, Wis.

One of the most difficult problems of this company is the heat treating of their automobile parts. This operation was formerly carried on in box type fuel fired furnaces. This involved heavy labor charges, large amount of floor space and high rejections, due to non-uniformity of temperature. They, therefore, decided to install an electric furnace.

The parts to be heated varied from a

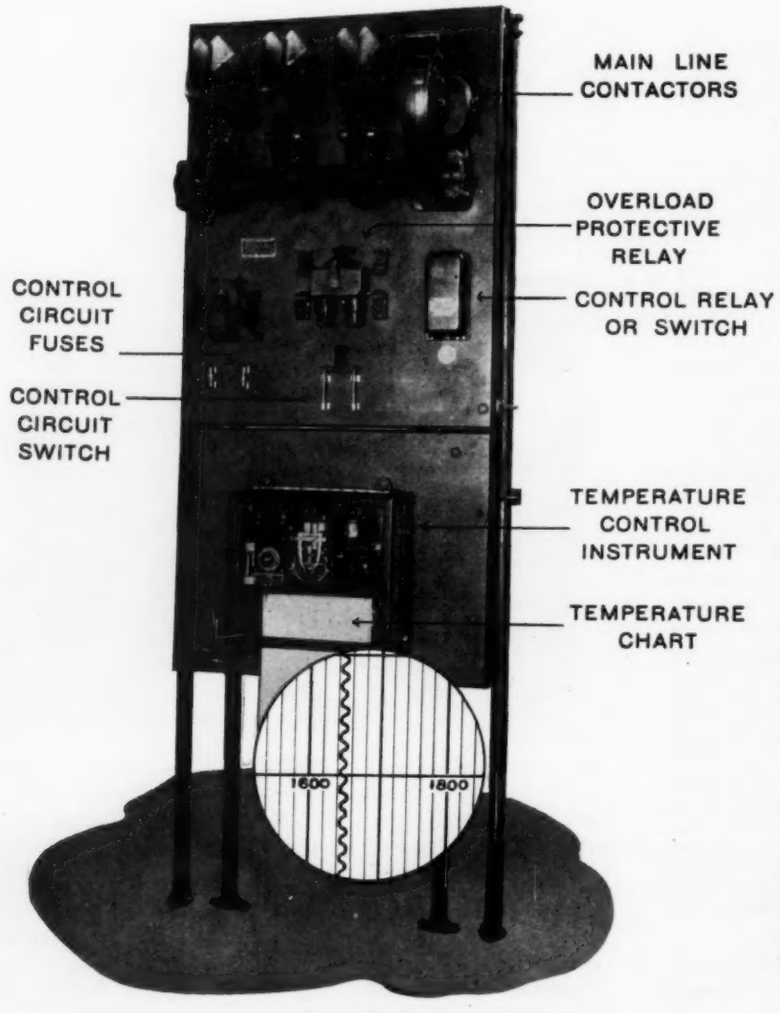


FIG 5

small spring clip to a large front axle. The rotary type furnace was finally selected. This consists of a moving hearth in the form of an annular ring. (Fig. 6). The rotating table is built up of structural steel members, heavily insulated, and has a refractory hearth. The table rotates on a series of 20 rollers, spaced at regular intervals about the circumference. Additional rollers are mounted radially on the central pedestal of the furnace and forms the axis about which the table rotates. The clearance space between the hearth and furnace walls is closed by sand seals to prevent infiltration of air to the furnace.

The table is driven by an adjustable speed motor, through suitable gears and a rack mounted on the bottom of the table.

The furnace is insulated with 10 in. of heat insullating material and inclosed in a steel shell suitably reinforced by structural shapers. (Fig. 7.) Two adjacent doors, pneumatically operated, are provided for charging and discharging. A baffle wall extends across the heating chamber between the two doors to prevent the heated pieces being chilled when cold material is charged.

The heating elements consist of nickel chromium ribbon, suspended from the side walls on special refractory insulators. The chamber is divided into two zones. The first section, or heating zone, extends approximately two-thirds the distance around, starting at the charging door, and has a connected load of 210

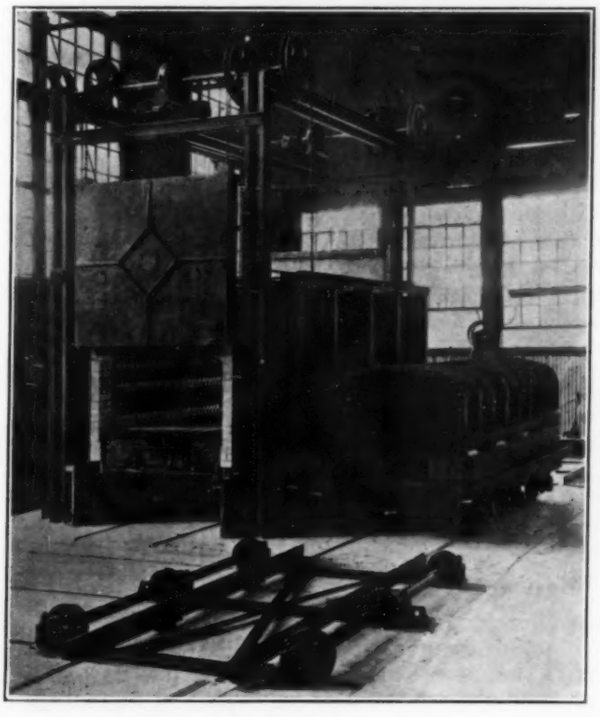


FIG. 5

kw. The last section, or finishing zone, extends the remaining third of the distance and has a connected load of 113 kw. The temperature of each zone is controlled automatically by means of a potentiometer controller, actuating an automatic control panel. The total connected load is 323 kw. for operation on 440 volts, 3 phase, 60 cycle. The outside diameter of the furnace is 19 ft.; outside diameter of rotating hearth is 15 ft.; inside diameter of rotating hearth is 5 ft. The hearth is 5 ft. wide. The total hearth area is 157 sq. ft.

The furnace is very flexible, as the parts treated vary in weight from 3 lbs. to 180 lbs. each. The time of heating the parts varies with the cross section. With the adjustable speed drive and the ease of varying the temperature setting of the control instruments, low price labor can be used to operate the furnace. A chart has been made up showing the posi-

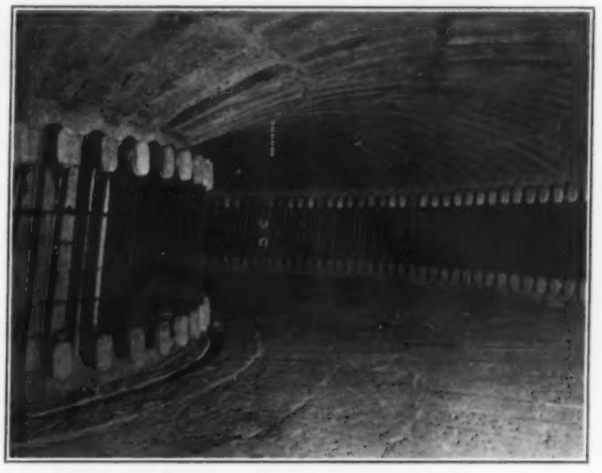


FIG. 6

tion of the controller handle and temperature setting for each piece. This eliminates depending on the operator for the heating cycle.

When operating on hardening, the furnace heats 3,000 lbs. per hour and the economy is 170 kwh. per ton at 1525 deg. F. At night the furnace is used for annealing and carburizing. A total of 18,000 lbs. of carborizing, boxes, packing and material is placed in the furnace at one time.

The furnace fits in nicely with the straight line production in the plant. Due to the temperature control and uniform temperature distribution in the furnace chamber, rejections due to faulty heat treatment are eliminated. Absolutely consistent results are obtained day after day. Scaling has been reduced and it is only necessary to give a flash pickle to annealed parts, whereas formerly the material was pickled for three or four hours. Smaller grinding allowances are permitted, thus saving material.

Due to the great success obtained with this furnace, and the low unit cost of parts treated, this company purchased three additional rotary furnaces for their Kenosha and Milwaukee plants. These furnaces have different hearth widths, namely, 17 in., 24 in. and 34 in. One of these furnaces is shown in Fig. 8. For one particular operation, they have reduced the piecework price 51 per cent.

A Large Automobile Company.

This company purchased a continuous conveyor furnace for the heating of ring gears. This installation was very successful, as they eliminated sand blasting the gears after treating. The scale is so slight that it can be removed by a wire brush. The labor cost was reduced, as two men handle 90 ring gears per hour.

Due to the success of this installation and the difficulty encountered with their carburizing, they decided to install electric furnaces for this class of work. After a careful analysis, they selected the rotary type

furnace. The rotating table is built up of cast sections, fastened to a central shaft and driven from the top of the furnace. The table is heavily insulated and has a tile hearth with alloy metal castings, equally spaced, to support the carburizing boxes. The hearth is supported and runs on steel balls, with additional rollers, mounted below its outside circumference, to provide for uneven loading.

The table is driven by an adjustable speed motor through suitable gears. The hearth does not run continuously, but is moved forward by operator pushing a push button. Signal lights are arranged so that operator can determine when a box is spotted in front of the door.

The heating elements consist of heavy nickel chromium ribbon, suspended from the side walls on special refractory insulators. The chamber is divided into five zones, each with an automatic control panel. However, there are only three control instruments. The first and second zones, starting from the charging end, are controlled by one instrument. The third and fourth zones are controlled by one instrument. The fifth or final zone has its own control instrument. With this arrangement, three temperature zones are established, which may be controlled independently of each other. Two furnaces were installed and each has a total connected load of 500 kw. for operation on 220 volt, 3 phase, 60 cycle.

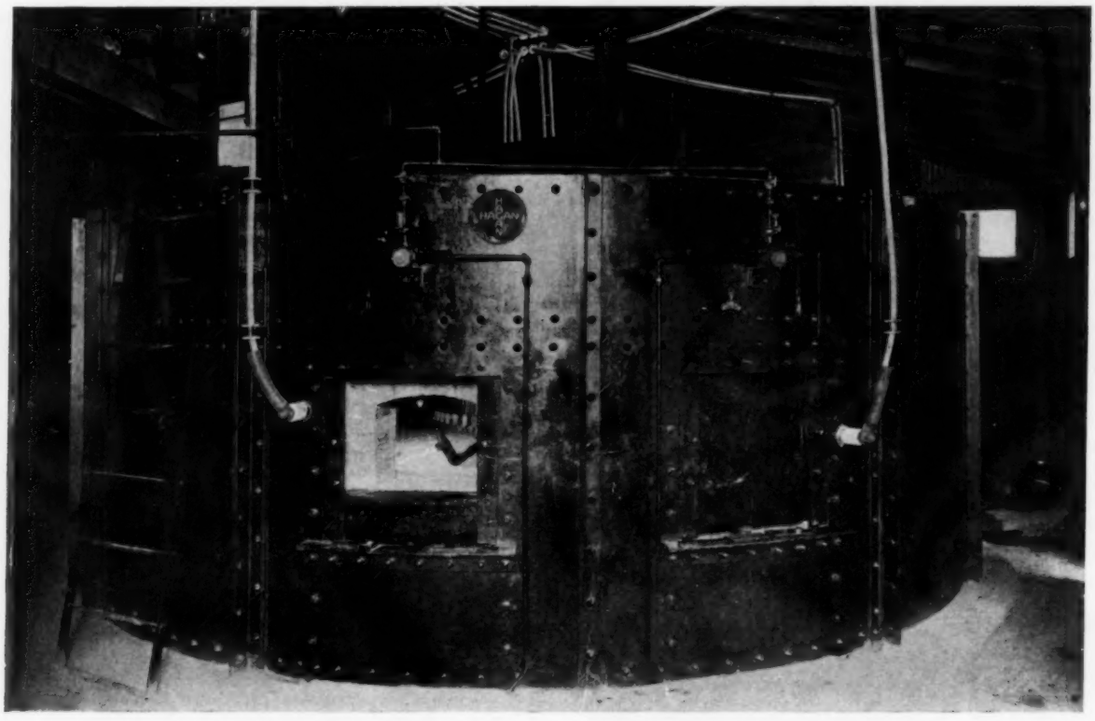


FIG. 7

The outside diameter of each furnace is 28 ft. The outside diameter of hearth is 22 ft. The inside diameter of hearth is 11 ft. 4 in. The hearth is 5 ft. 4 in. wide. The total hearth area is 287 sq. ft.

The time cycle in the electric furnace is 12 hours, as compared to 15 hours in the oil fired furnaces for the same size and weight of box. This has naturally increased the efficiency of the operation. A typical month's work in the electric furnaces shows a total of 1,635 gross tons heated and the economy to be 200 kwh. per gross ton. This actually gives a lower fuel cost than obtained from 25 oil fired furnaces, operating in the same department, at the same time, and on the same class of work. The saving in fuel and labor represents a return on the investment for the two electric furnaces of 81.7 per cent in 12 months.

The fuel fired furnace operators are paid three times the piecework rate per box of the electric furnace operators. Both labor crews earn the same wages per day. In spite of this, the daily wages of two operators on the two electric furnaces exceeded the wages of the operators on the fuel fired furnaces To avoid labor trouble, three men per shift are used on the electric furnaces, although two men can operate both furnaces.

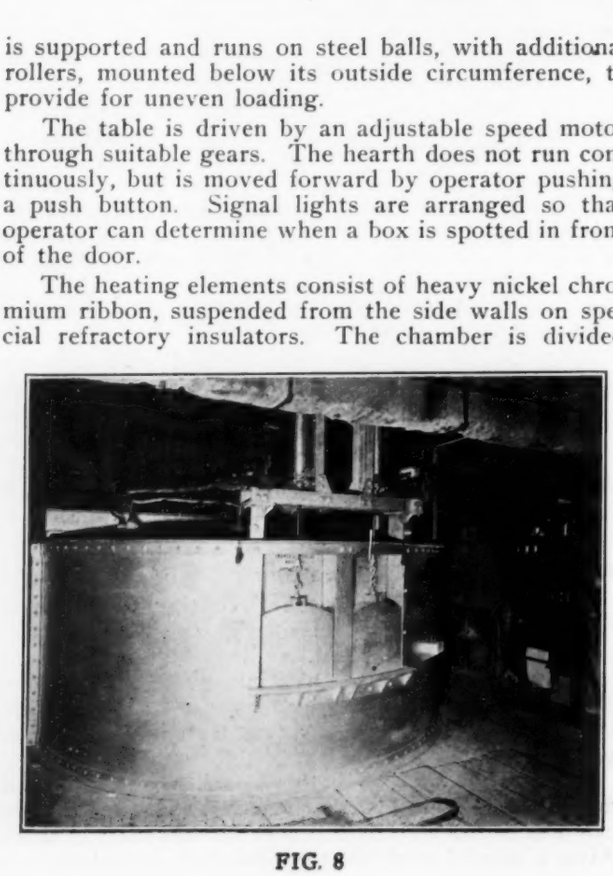


FIG. 8

The above saving does not take into consideration the quality of the work or the saving of floor space. It has been found that pieces of different cross section and different weight can be charged in the same box and boxes containing pieces of different cross section and weights can be charged at the same time. This was impossible with the fuel fired furnaces and naturally this interfered with production. It was also necessary to sample one piece of each charge in the fuel fired furnaces, to determine if the proper depth of case had been obtained. With the electric furnace, this has been eliminated, as they are operated on a definite time and temperature cycle.

Other Rotary Furnaces.

A large number of rotary electric furnaces are installed for heating various materials. This type of furnace lends itself to a large production of similar pieces. All installations show a big saving in floor space and a low labor cost, due to the ease of handling materials. They also readily tie in with automatic charging and discharging.

Remarkable savings have been shown in all cases. One installation of a small 30-kw. furnace, selling for less than $4,000, shows a saving of $65 a day. This saving results from the electric furnace, operated by one girl, replacing seven to eight highly skilled operators. (Fig. 9.)

A special application of rotary electric furnace is shown in Fig. 10. These furnaces are used for hardening and drawing automobile main drive shafts. The shafts are charged through an opening in the top of the furnace by means of an air hoist and automatic tongs. Adjacent to and part of the equipment is a revolving quenching tank. The movement of furnace and tank is controlled by the operator. The furnaces hold 60 shafts and the quenching tank holds 8 shafts. The air hoists are mounted on structural supports, revolving around a vertical shaft.

The operation is as follows: Number one operator removes the shaft from the hardening furnace and swing his air hoist to the quenching tank. At the same time, number two operator removes a shaft from the drawing furnace and deposits it on a rack. Number one operator removes a shaft from the quenching tank, swings the air hoist to the drawing furnace and places shaft in furnace. Number two operator picks up cold shaft with air hoist and deposits it in hardening furnace. From this point, number one operator repeats the operation of number two operator and vice versa.

These furnaces are located in the production line and show a large saving in labor and floor space. There have been no rejections due to lack of temperature control or non-uniformity of temperature.

Royal Typewriter Company.

This company had been having difficulty with the excessive wear on their typewriter parts. They felt that this was chiefly caused by poor temperature distribution in their combustion furnaces. After a careful investigation, they selected a box type electric furnace.

This furnace has firebrick walls, insulated with a minimum of 10 in. of insulating material. The whole is enclosed in a steel shell, which is flanged for stiffness and reinforced with structural shapes. (Fig. 11.) The outside surface is smooth, as the usual projecting members are eliminated. The whole is supported on 12-in. I-beams, thus making the furnace portable, as it can readily be moved from place to place.

The door is counter-balanced and arranged for hand operation. Chain sheave door assembly is carried on self-aligning ball bearings, in order to insure smooth operation, with minimum effort on part of operator. Suitable lugs along the sides of the furnace effectively seal the door against the front of the

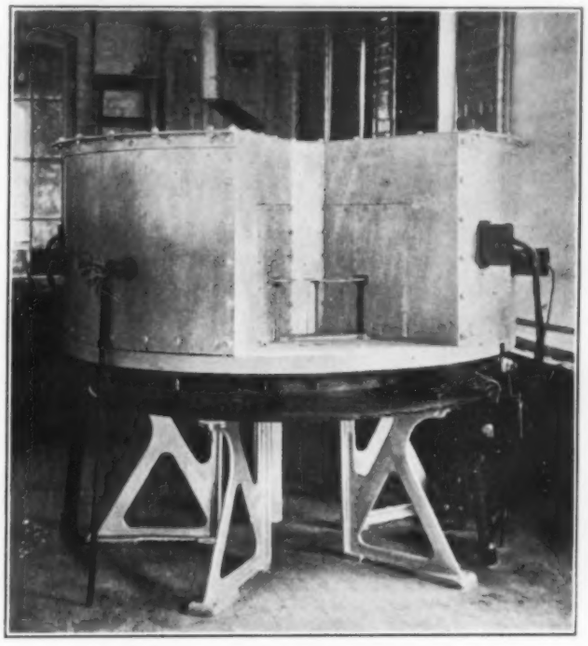


FIG. 9.

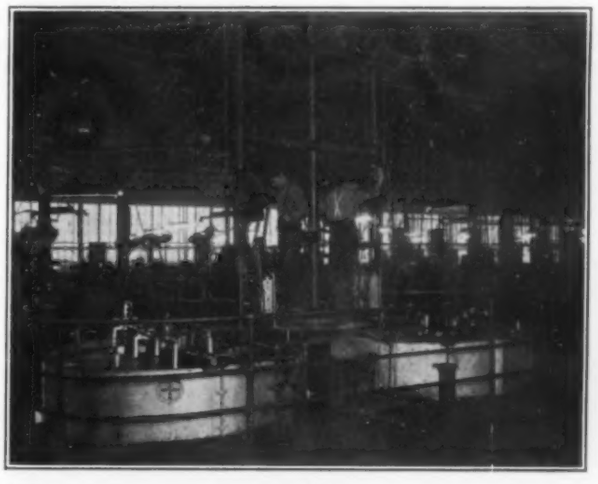


FIG. 10

furnace when closed. The door is lined with heat resisting cement, backed by insulating material.

The furnace inside dimensions are 4 ft. 10 in. long, 3 ft. wide and 2 ft. high. The total connected load is 60 kw., 220 volts, 2 phase, 60 cycle. The heating elements consist of heavy nickel chromium ribbon, suspended from side walls by special refractory insulators. The temperature of the furnace is automatically controlled by means of a potentiometer recording controller, actuating an automatic control panel.

The operating temperature is 1650 deg. F., and the average gross charge is 1100 lbs. The heating time is 5 hours and the economy is 360 kwh. per gross ton. The cost of electricity is higher than the cost of fuel with the old furnace. However, this is offset by the quality of the product. It was impossible to carburize the slide rail of the typewrter in the fuel fired furnaces due to warping. With the uniform temperature obtained in the electric furnace, this difficulty has been eliminated.

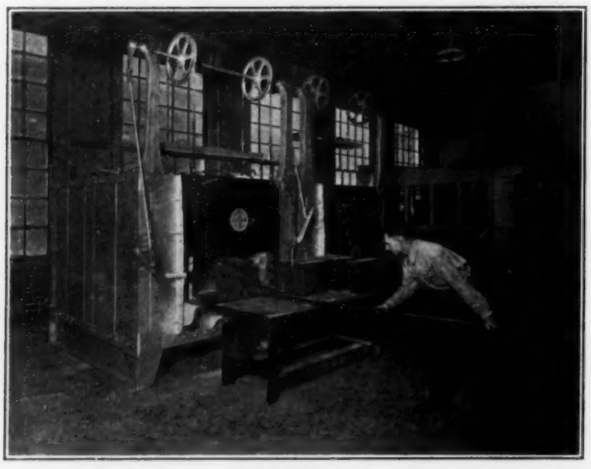


FIG. 11

The first furnace was so successful that at the end of six months the second furnace was purchased. The furnaces have been operating for approximately two years, and to date they have not had a single rejection due to faulty heating.

Whitin Machine Works, Whitinsville, Mass.

The products of this company consist of textile machine parts. They formerly did their carburizing and annealing in oil-fired furnaces. The cost of handling materials and rejection was high and it was decided to scrap their old furnaces and put in up-to-date equipment.

FIG. 12

After an investigation, they purchased six box type electric furnaces. At the start it appeared that the car type furnace was the best, as far as the handling of materials was concerned, but a car type furnace is not particularly adapted to carburizing work. The electric storage battery lift truck was the answer to the difficulty of handling heavy carburizing and annealing boxes in the box type furnace. The lifting platform of the truck has a fork mounted at the end which can be run under the boxes. In handling small boxes, a number are placed on a plate, and thus charged into furnace. (Fig. 12.)

Five of the six furnaces are shown in Fig. 13. Each furnace has its own control and all six control equipments are located in one control room. An interior view of the furnace is shown in Fig. 14. In addition to the furnaces, they have installed a regenerative oven. They anneal in boxes and after the box is removed from furnace, it is placed in the oven. The oven is so designed that a cold box is placed above the hot box, thus obtaining a preheat for the cold box, which increases the efficiency of the equipment.

Van Dorn Iron Works Company, Cleveland, Ohio.

This company carburizes jail rods and hardens automobile bumpers. This work was formerly performed in a coke fired furnace, and it was impossible to obtain a uniform case on a rod 10 ft. long. They therefore purchased an electric furnace for this work.

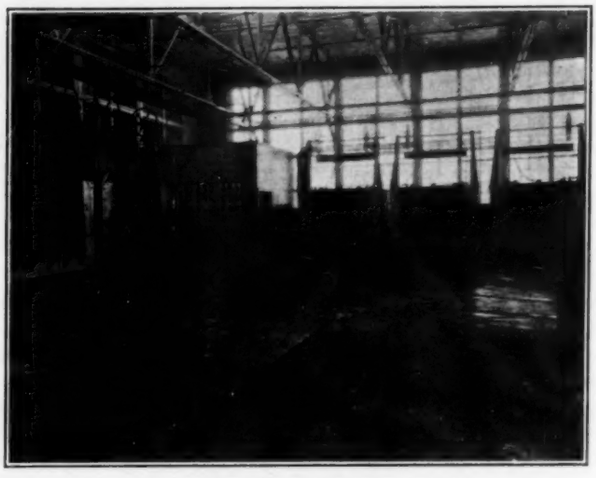


FIG. 13

The furnace selected was a box type with a door at each end. The heating chamber is 12 ft. long, 3 ft. 9 in. wide and 2 ft. high. The total connected load is 123 kw. for operation on 440 volt, 3 phase, 60 cycle. The operation was so successful that within the year a second furnace was installed. Number two furnace is the same as number one furnace, except that it is 18 in. wider. Six months later, two additional furnaces were installed. Furnaces 3 and 4 heating chamber dimensions are 6 ft. 9 in. long, 3 ft. wide, 2 ft. high. Each furnace has a connected load of 65 kw. for operation on 110 volts, 3 phase, 60 cycle. The four furnaces are in the same room (Fig. 15), and operate 24 hours a day, seven days a week.

With the coke fired equipment, the depreciation on the carburizing boxes was very high. With the electric furnaces, they have stopped using the heavy cast boxes, and instead use light 20-gage sheets. The sheets are bent to shape from a straight sheet, without notching. The bottom and sides are folded over to form a three-ply end for the box. A cover of the same material is made to fit tightly over the box.

Suitable U clamps, made of 7/8-inch hexagon bar, placed over the top and sides, hold the box in shape. The box is placed on a quarter inch plate. The plate has a large hole at ends, by means of which the plate and box are drawn in and out of furnace by an electric hoist. The use of this light box increases the

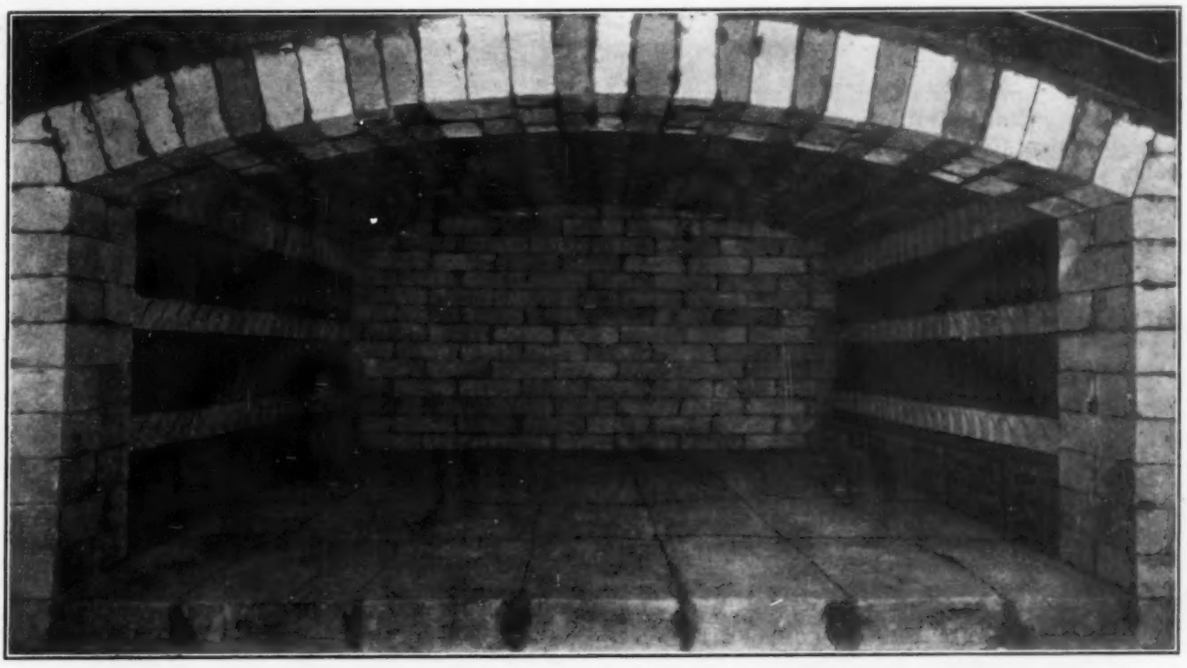


FIG. 14

efficiency of the operation, as it is not necessary to heat the heavy cast box, and the heating cycle has been decreased. The heating cycle is 12 hours.

The savings effected by the electric furnaces are large, but cannot be entirely evaluated. The saving in labor of two men is over $4,000 a year. There is a saving in repairs and maintenance, but the real value of the furnace is the aboslute certainty that the temperature is uniform throughout the furnace chamber and that the furnace is held at the temperature desired. There have been no rejections or reheatings due to faulty heat treatment.

The power factor of the plant has been materially increased by the operation of the electric furnace. The heating elements operate at unity power factor. This has increased the plant power factor by more than 30 per cent and, in turn, decreased the cost per kwh. for the whole plant.

Other Box Type Furnaces.

There have been more box type electric furnaces installed than any other type. The sizes vary from the small laboratory furnace to the large size working on a tonnage basis.

Of particular interest is a box type furnace operating in the heat treating room of a large tube mill. This furnace is used for hardening dies. Before purchasing the equipment, tests were conducted in a small electric laboratory furnace and results compared with test conducted in an oil fired furnace. These tests showed increased die life of 18 to 20 per cent in favor of the electric furnace. A furnace 5 ft. 7 in. long, 27 in. wide and 2 ft. high, having a connected load of 60 kw., was purchased. Since this furnace has been in operation, it is evident that they will obtain an increased die life of 33 per cent at least.

Another installation of interest is in the heat treating room of a large pipe mill. This furnace is used for hardening and drawing pipe threading dies and shear blades. This furnace has met with great success, due to the increased production obtained and its flexibility. The temperature required for the work varies during the day. It only requires two minutes to change the temperature setting on the control instrument, and the furnace being "snappy," readily responds to different temperature settings.

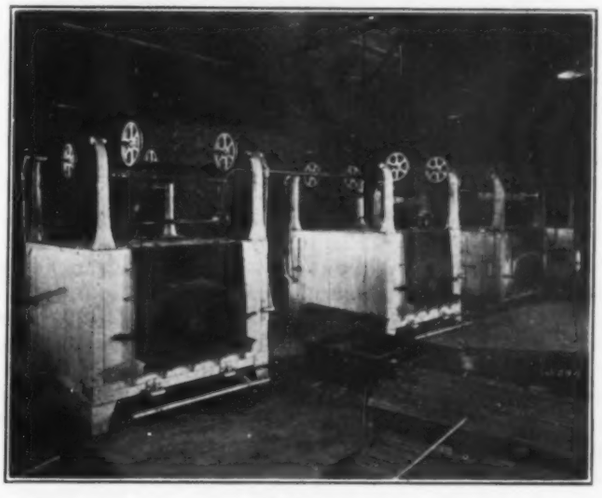


FIG. 15

Vitreous Enameling Furnaces.

The electric furnace has met with its greatest success in the vitreous enameling industry. The electric furnace atmosphere is slightly oxidizing, which is ideal for this class of work. There are no fumes or

dirt which will discolor the ware. The temperature distribution is even so that all parts of the ware receive the same burning. The production is greatly increased for the same hearth area. Materials can be charged and discharged on a definite time and temperature cycle, giving a uniform product from day to day. The source of heat is clean, eliminating the dirt which prevails in firing rooms equipped with combustion furnaces.

The furnaces described in the following paragraphs consist of a main or upper burning chamber, with an auxiliary or lower burning chamber (Fig. 16). The heating elements consist of heavy nickel chromium ribbon suspended from suitable refractory insulators mounted in the side walls. Each chamber (upper and lower) has its own control instrument and automatic panel. The work is supported on racks, which rest on ledges at each side and a central pier.

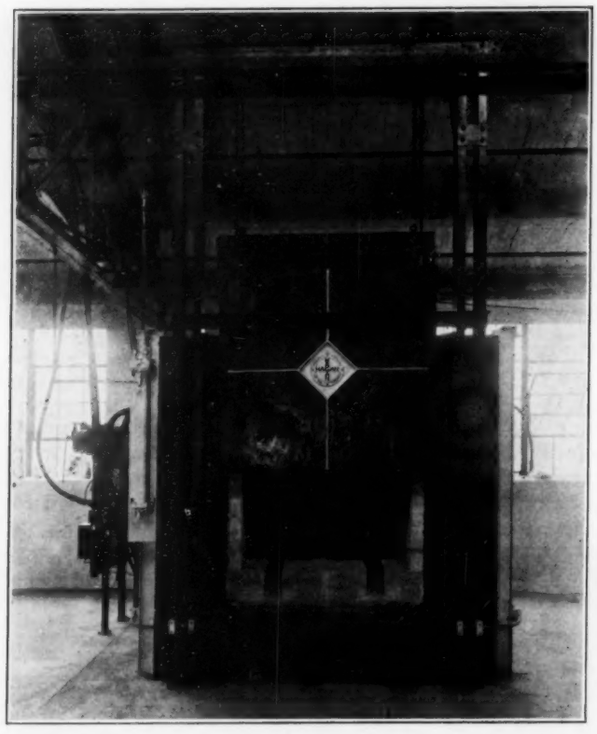


FIG. 16

A large sanitary plant has six electric furnaces enameling bath tubs. Each has 200 kw. connected load and is capable of production of four 225-lb. tubs per hour. Over a long period of time they average 3.6 tubs per hour. The average production in combustion fired furnaces is 1½ to 2 tubs per hour. Due to the uniform temperature of the furnace, it is not necessary to turn the tubs end for end after each burning. The increased production, elimination of rejections and the economy of 48 kwh. per tub gives a lower cost per perfect tub enameled.

In the kitchen ware branch of the industry, the same general results have been obtained. Fig. 17 shows two furnaces built back to back. Two such furnaces replace three coal-fired furnaces. Each furnace will produce 20 to 22 charges per hour, as against 15 to 16 charges per hour in a coal fired furnace. The electric furnace can be brought from cold to 1675 deg. F. in 10 hours. When shut down at 7A.M. on Sunday, the temperature will fall to 1250 deg. F. by 4:30 A.M. Monday and will come back to temperature of 1675 deg. F. in two hours.

A remarkable development of the electric furnace is shown in Fig. 18. With this furnace and speed fork, the usual burning racks have been eliminated.

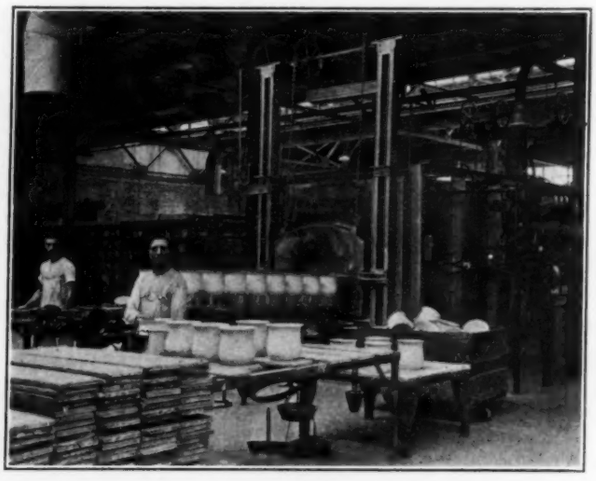


FIG. 17

Ordinarily, the burning rack weight is 2½ to 4 times the weight of the charge. These racks are forked in and out of the furnace with the charge. It is evident if they could be eliminated, the efficiency could be increased.

The furnace hearth consists of rows of high grade alloy castings, extending the full length of the chamber and equally spaced across the chamber. These castings have a series of points three or four inches high, equally spaced the length of the casting. The charging fork has a number of forged fingers with steel points; having the same spacing as the points in the furnace. The fork fingers are so spaced that

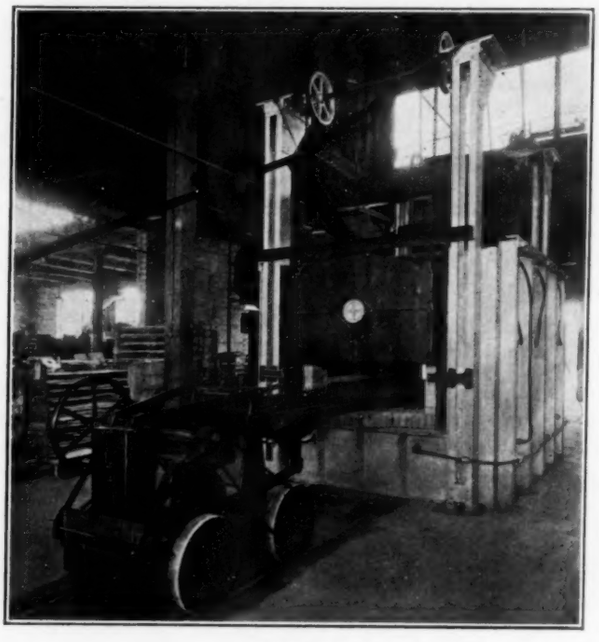


FIG. 18

when moved into the furnace, will pass between the rows of castings. The charging fork carriage is driven by a hand wheel, chain and sprocket, and moves up to and away from the furnace on rails set in the floor. The carriage also has a vertical lever by which the fork fingers can be raised and lowered six inches.

The furnace has a door and speed fork at each end, and is operated by two men (one at each end). The material is loaded at one end and is unloaded at the other. This gives practically a continuous furnace without the use of a conveyor. The furnace is particularly adapted to sheet metal ware.

The furnace is 8 ft. 6 in. long, 4 ft. wide and has a connected load of 180 kw. With two men operating the furnace, an average production of 29 heats per hour can be maintained when working on 22 gage sheet steel. By eliminating the reheating of the burning racks, an economy of 9 lbs. (net ware), per kwh. is obtained.

Medium and Low Temperature Applications

By E. A. HURME*

SINCE the organization of the Association in 1906, we have made great progress in our purpose to attain more economical production of iron and steel products by the application of electricity to the industry. Electric motors have been successfully and economically applied to practically every main roll and auxiliary drive. The electric arc melting furnace has been developed to the point where it is recognized as being superior to the other methods for the production of high grade and alloy steels and for melting steel scrap. This has been made possible largely by the work of the members of this Association. There are, however, in the manufacture of iron and steel products, many heating processes at present using coal, gas, or oil fired furnaces, to which electricity could be applied at a saving in cost and with an improvement in the quality of the product. In the past this large field for the application of electric power has been almost entirely overlooked by the Association in our efforts to promote electric drive to rolling mills, where its advantages were perhaps most apparent.

It was not until 1914 that any considerable interest was shown in the use of electric heating equipment. By 1918, the importance of this field began to be realized by the central stations and electrical manufacturers began to develop apparatus to meet the demand. Since that time it has developed by leaps and bounds.

It seems to be the prevailing opinion that electric furnaces are out of the question when compared to fuel fired furnaces on the basis of cost. Mr. C. F. Collins has given in the transactions of the American Society for Steel Treating for January, 1924, some comparative figures on the operating cost of electric and oil fired furnaces, which are not unfavorable to the electric furnace.

The comparison is made between a furnace burning oil and one using electrical energy produced by coal burned under boilers in a modern power plant.

Starting with an amount of coal and oil each containing 20,000 Btu., the cost of oil at 7c per gal. is $.01 and the equivalent amount of coal at $5 per ton based on 12,500 Btu. per lb. is .004c and allowing for power plant overhead is .00425c. An efficiency of 17 per cent is reasonably high for an oil fired furnace so that approximately 3,400 Btu. would be utilized.

Modern power stations can easily develop 1 kwh. from 1½ lb. of coal so that approximately 3,840 of the 20,000 Btu. in the coal can be expected to be converted into electrical energy. The efficiency of the electric furnace is high and with an efficiency of slightly better than 80 per cent, 3400 Btu. will be utilized which is the same amount as was utilized with the oil fired furnace. The cost, however, of the 3400 Btu. in the oil fired furnace is $.01 while in the electric furnace it is $.00425.

These conditions may not be realized in every case, but the figures indicate that with efficient power plant equipment and properly designed furnaces, the electric furnace can compete on a cost basis with one burning oil. In many cases where cheaper fuel can be used, the comparison will be less favorable to the electric furnace, but usually improvement of the product or reduction in labor cost will justify the difference in the cost. In fact, for many applications the cost of fuel is secondary to the accurate control of temperature, for which the electric treating furnace is ideally suited.

The field of industrial heating can be divided into two classes; the medium and low temperature applications. The medium temperature units are ordinarily classed as furnaces and operate at from 1,000 deg. to 2,000 F., while the low temperature units are classed as ovens and operate at temperatures below 1,000 deg. F.

Medium Temperature.

Medium temperature furnaces are used in the iron and steel industry for annealing sheets for stamping, for annealing and removing strains in castings, for annealing or hardening wire, and for the hardening and tempering of steel parts and tool steel.

Medium temperature furnaces are now on the market in a wide range of sizes adapted to nearly all industrial heating processes. The furnace chamber sizes vary from bench type to the large car type annealing furnaces 20 in. high x 4 ft. wide x 15 in. long and the load range from 1½ to 2000 kw.

*Manager Steel Mill Section, Westinghouse Electric & Mfg. Company, East Pittsburgh, Pa.

Fig. 1 shows typical construction of small floor mounted muffle type furnaces. These furnaces are simple in construction, consisting essentially of a sheet steel box lined with refractory brick. The heating elements are "S" bend coils of nickle chromium wire mounted on the outside of perforated muffle plates of refractory material which form the heating chamber. By this means of construction the heating elements are protected from injury by the material to be heated and uniform distribution of temperature is maintained. The bottom muffle plate is sometimes protected by a sheet of nickel chromium alloy.

These small hearth type furnaces are built for connecting direct to 110 or 220 volt supply lines through suitable control apparatus. They can be equipped for manual control of the temperature by the use of a rheostat and transformer or by an auto transformer with a tap-changing switch.

One of the chief advantages of the use of electric heat lies in the fact that the cycle may be made en-

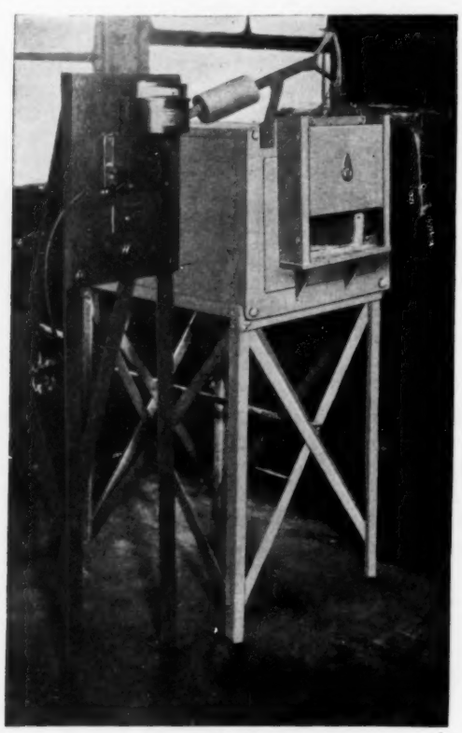


FIG. 1

tirely automatic. The automatically controlled electrically heated device requires no attention during the process of heating. Also a given operation can be duplicated as often as desired. These features cannot be obtained to the same degree with any other form of heat.

Application of Small Medium Temperature Heat Treating Furnaces.

These small hearth type furnaces are especially suited to applications requiring continuous temperatures not over 2,000 deg. F. (1,000 deg. C. approximately). Among the usual jobs performed in this type furnace are the following:

Annealing, hardening carbon steel, normalizing, case and pack-hardening, drawing temper of high speed and alloy steels, vitreous enameling and laboratory applications.

For many applications very slow heating is essential. In these cases a reduced input transformer and tap changing switch panel should be used. This may be used in addition to automatic temperature control, but it should never be the only means of control except where close personal supervision of the operator is assured.

With manual control failure of the operator to turn off the current when the temperature reaches the

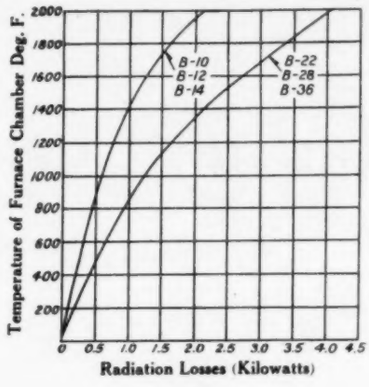


FIG. 2

critical value, will result in the destruction of the furnace.

The figures below show approximate performance curves for a bench type and floor mounted furnace of the hearth type.

Fig. 2 shows the radiation losses for various furnace temperatures. Fig. 3 shows the time required to heat up the furnace from room temperature to any particular temperature for which the control pyrometer may be set. Fig. 3 is based on the furnace chamber being empty. The time required to bring up to temperature a cold charge will of course depend on the kind of material to be heated, the average size of the piece and the total weight of the charge. The

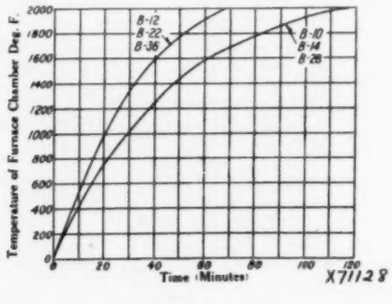


FIG. 3

furnaces can be equipped with a time clock to start heating the furnace in the morning so that it will be heated when the workmen arrive.

In the application of a furnace to a particular process, it will usually be found best to leave the selection of the proper size to the furnace manufacturer on account of the various factors involved. Knowing the kind and amount of material to be treated per day and the temperature desired, the furnace manufacturer will be able to select the most economical size furnace and to accurately predict the performance, which will not depend upon the skill and experience of the operator as with a fuel fired furnace.

Installations of Hearth Type Tool Treating Furnaces.

One of the most successful applications of the hearth type industrial furnace is in the treating of tool steel. In a paper presented before the Philadelphia Section, December 1, 1923, which was published in the February issue of the "Iron and Steel Engineer", Mr. J. F. Jelly described the electrical process used at the Phoenix Iron Company plant for the treating of punches and dies used in the fabricating shop.

Dies used in forming small parts by the die casting process are subject to very high stresses and require special heat treatment.

For this exacting work, the Sanitary Tube & Stopper Company have adopted the electric furnace; and find that they not only get better tops, save effort in heat treating their dies, but actually save $100 on each set hardened. It costs about $100 to make a set of dies, and as heat treating in the electric furnace more than doubles their life, the process saves the cost of a new set of dies.

The tops, formed with the dies, which consist of a cap and a bottom part, are extended from round blanks or slugs. The material used is a tin-lead-antimony alloy. The bottom parts are completely formed, except for the threads, in a single operation, under a pressure of 60,000 to 70,000 pounds. This operation

FIG. 4

includes the forming of the flange, which usually contains delicate ornamental designs, and the piercing.

These pieces are turned out at the rate of almost one per second. It is evident that dies, operating at this speed and under such tremendous pressures must be hard and true and without flaw, in order to produce uniform results.

The caps are made in one operation on the punch press. The blank, which is about ⅜-in. dia. x ⅛ in. thick is placed in the die block. A punch having threads, comes down from above, and another punch which is formed to shape the top part of the cap, comes up from below. Under a pressure of 40,000 pounds, the metal is squeezed through the narrow spaces separating these punches and the die block. As the upper punch is withdrawn, it revolves and thus frees itself from the cap, which has been completely formed in this one operation. This machine makes 55 caps per minute.

In both of these operations, the actual stresses in the punches, and dies are almost impossible to calculate, but they are certainly very high. Any flaw in the steel, or any cracking or warping, caused by heat-treatment, will show up in very short order.

The threads on the bottoms of these stoppers are rolled. This is another operation requiring high grade dies. Unless the proper material has been used, and it has been carefully heat-treated, it will soon become dull and form poor threads.

The Westinghouse Type L furnace, which is being used to heat-treat the tools, punches and dies, has been giving excellent results. Electric heat is the ideal heat, because it is so evenly distributed throughout the heating chamber, and because it is so uniform. When a piece of steel is placed in the furnace, it comes up to temperature evenly. There is no flame striking one

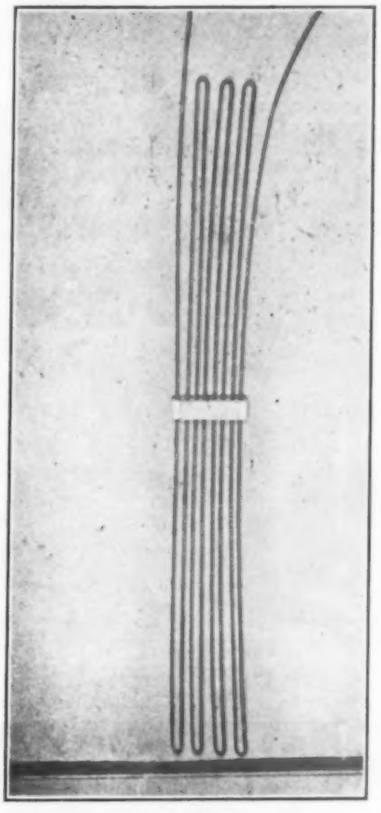


FIG. 5

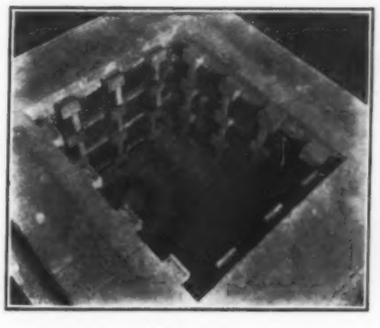


FIG. 6.

part of the piece, heating it more rapidly than the rest, and thus causing warping. It is possible to keep the temperature at just the right point, as long as desired. We can be sure of quenching at a "holding" heat or "rising" heat. Thus chrystallization caused by quenching at a decreasing temperature, is avoided.

With the electrical equipment they are getting about one and one-half million tops from each set of dies. With the best gas-fired equipment they could not expect to get half as many pieces; and of the tops

they would get there would be many more poor ones.

The Eclipse Interchangeable Counter Bore Company, of Detroit, Mich., is obtaining very satisfactory results treating hardened steel cutters in an electric furnace.

Tool Steel Tempering Furnace.

An electric furnace was installed in this plant a couple of years ago for drawing the temper of high-speed cutting tools. The primary reason for the installation was to secure a higher quality product than was found possible with the fuel fired furnace.

The work done in this furnace is mostly drawing

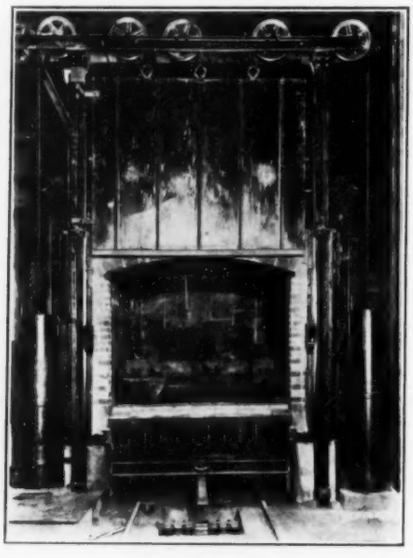


FIG. 7

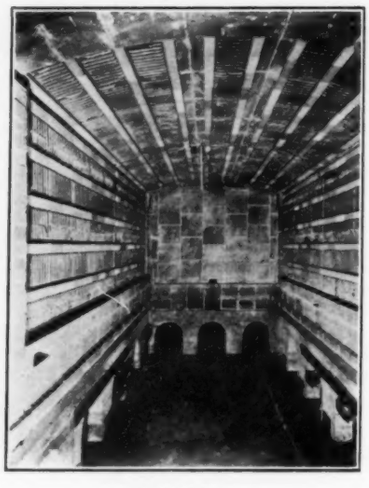


FIG. 8

the temper of high speed hardened steel cutters. An average charge consists of 300 cutters weighing approximately 75 pounds. With the furnace at a temperature of 1100 deg. F., the cold work is charged into the furnace and the temperature of 1100 deg. is recovered in 40 minutes' operation. This value is held for 20 minutes during which time the temperature does not exceed the limits of 1092-1137 deg. F.

The user of this furnace states that they are obtaining a product of much better quality with the electric furnace. This is possible because the rate of heating is under definite and accurate control which was impossible with the fuel fired furnace. The ideal heating cycle for this class of product is approximately 40 minutes from room temperature to 1100 deg. F. This cycle is closely approximated in the electric furnace, making possible laboratory results in routine shop practice. A rapid rate of heating as obtained with a fuel furnace was found to be detrimental to the tool because it caused surface checking and cracking. Some of these defects were discovered in inspection but some which escaped discovery ultimately failed showing up the defect. Since the installation of the electric furnace the rejections have been practically eliminated and there have been very few failures of the tools in service traceable to defects caused by the heat treating process.

Actual operating costs have not been given out on this installation but it was stated by the operators that in addition to the improvement in quality, there was also a considerable saving in operaing cost over the old fuel fired furnaces. The saving is due to the saving in operators' time due to the automatic control of the tmeperature and to the increased number of heats possible per day.

Large Size Medium Temperature Furnaces.

Large industrial electric furnaces are used for a wide variety of processes, the most important in iron

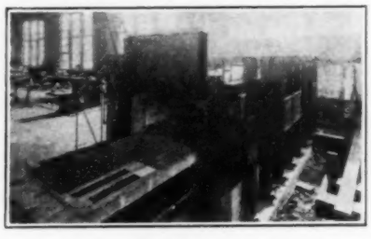


FIG. 9

and steel plants being the annealing of large castings, the annealing of sheets for stamping, hardening and tempering wire and steel springs and hardening of steel parts.

Where the process will allow, as in annealing wire, the process is made continuous. In some cases a preheating chamber is used in which a cold charge entering the furnace is allowed to come up to temperature slowly while another charge is coming to the final temperature in the adjacent chamber. Each process presents a particular problem for nearly all of which electric heating engineers are now equipped to offer an economical and satisfactory solution.

One type of furnace construction will be seen in Fig. 4 showing the interior of a large pit type furnace. The heating elements consist of "S" bend coils as shown in Fig. 5 made of nickle chromium alloy. The coils are supported by cleats which are inserted between "T" shaped refractory bricks built into the furnace wall. It will be noted that this type of construction makes it very simple to put the heating elements in place. The photo Fig. 4 was taken after one and one-half years in service. Where larger input is desired a double banked arrangement of coils can be used as in Fig. 6. The heating elements are built in standard lengths which can be combined to give practically any input desired for standard voltages.

When the temperatures required are above 1800 deg. F., the furnaces are sometimes built in two sections. The first is a preheating chamber using metal heating elements which brings the charge up to 1800 deg. F. It is then raised to the desired temperature in a second section heated by carbon resistors.

Furnaces for Annealing Castings.

A car type annealing furnace shown in Fig. 7 is installed at the plant of the Keokuk Steel Castings Company. It is 4 ft. wide 6 ft. high and 10 ft. long. The furnace is shown with the car in place loaded with steel castings ready to be annealed. An interior view of the same furnace is shown in Fig. 8. The heating elements in the walls and roof are covered with baffle plates. Heating elements installed in the car bottom itself are supplied with current through the contact shoes shown on the side. For the annealing of castings this type of electric furnace offers many advantages over fuel fired equipment. The product is more uniform due to accurate control of the temperature, and attendance and maintainance costs are lower.

Following is a description of the annealing furnace installation of the Canadian National Railways Company:

The Transcona shops of the Canadian National Railways installed in 1923 a car bottom type electric furnace for annealing the vital parts, such as side rods, driving gear and coupler pockets of locomotives and

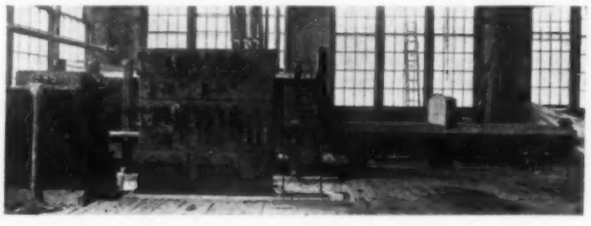


FIG. 10

cars. Continuity of operation and insurance against possible accidents were the primary factors considered in making this installation. Prolonged service under the severe stresses to which these parts are subjected would often result in ultimate and sudden failure due to fatigue and consequent crystallization of the internal structure. The possibility of accident, due to this cause is minimized by removing the internal stresses in the material.

The average charge treated is 5 tons and the average weight of the pieces treated is over 150 lbs. The car bottom type electric furnace was chosen for the work because of its economy and the necessity for accurate control of the temperature. The furnace is shown in Fig. 9 with the car partly withdrawn and with several of the alloy floor plates and refractory plates removed to show the heating elements, running lengthwise of the car bottom. Heating elements are also mounted on the sides and roof of the furnace. Fig. 10 shows the car completely withdrawn with the transformer, automatic control panel and the recording pyrometer. The heating elements are divided in two three-phase groups and the dividing baffle shown on the car makes it possible to operate half the furnace at a time, when necessary. The inside dimensions of the furnace are 15 ft. x 4 ft. x 20 in. and it is designed for a normal charge of 5 tons at 1650 deg. F. The annealing operation consists of distributing the charge evenly over the car bottom and applying full input of 200 kw. until the furnace temperature reaches the value desired. The input is then reduced by changing the voltage taps on the transformers and the temperature is automatically maintained at the proper soaking temperature. The input supplied during the holding time is just sufficient to balance the radiation and other losses of the furnace. The pyrometer gives a

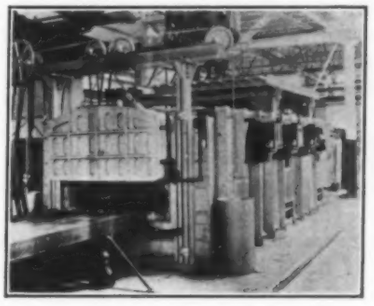


FIG. 11

faithful chart of the entire temperature cycle and the wattmeter tells the story of total input.

The following chart shows the input during a typical annealing cycle, treating coupler pockets to a temperature of 1300 deg. F.

Charge Lbs.	Time	Input Kw.	Kwh.	Conditions
12320	¢ hr. 10 min.	221	1360	Bringing charge to 1300° F.
12320	1 hr. 0 min.	60	60	Holding at 1300° F.
12320	Not stated	..	..	Temp. allowed to drop to 1200° F.
12320	1 hr. 0 min.	60	60	Holding at 1200° F.

The cost of power at .006 per kwh. is 1.44 per ton and the cost of power for each pocket treated is 10c. The production of the furnace is 8.34 lbs. per Kwh.

Other costs chargeable to the annealing operation include the handling of parts on and off the car bottom at $8.00 per charge. The cost of handling is roughly the same as the cost of power, bringing the total cost to approximately $3.00 per ton. The cost

FIG. 12

of power varies somewhat, depending on the class of material treated and the size of the charge.

The furnace has been giving excellent satisfaction and records of the Canadian National Railways shows that the treatment of these parts in the electric furnace is amply justified.

The French Manufacturing Company of Waterbury, Conn., has recently installed an electric annealing furnace which has many advantages over the old fuel fired furnace as will be seen from the following account.

The French Manufacturing Company recently replaced a wood-fired muffle type annealing furnace with a 330 kw. electric furnace after a very careful investigation of operating costs and comparison of the metallurgical results to be obtained by both methods. This particular furnace is used for annealing seamless brass tubing. The essential factors to be considered, however, are in many respects the same as for annealing iron and steel parts.

At a cost of 2-1/3c per kw. preliminary estimates indicated that the cost of electric power would not exceed the cost of fuel by more than 10 per cent. With the electric furnace less oxidation of the material was expected. This would result in a decrease in the time and labor in the subsequent process of pickling, as well as a decrease in the amount of metal lost by oxidation. More uniformly annealed product was considered as an advantage of the electric furnace. All these results have been obtained and the electric annealing process is not only cleaner, more satisfactory and more easily conducted, but shows a substantially lower cost of operation.

The furnace chamber is 16 ft. x 54 in. x 18 in. with an 18 in. vestibule at the front end and the walls are of insulite brick 16 in. thick. The coils are mounted in the walls, roof and floor. The floor coils are covered with alloy floor plates which support the alloy rails

FIG. 13

on which steel pans holding the charge are moved into the furnace by a motor driven charging device. Figs. 11 and 12 show the furnace installed. Power is supplied at 230 volts, 3 phase, 60 cycle. The coils are divided into two groups of 165 kw. each controlled independently by a separate pyrometer and control panel which keeps the load balanced.

In the operation of the furnace, all guess work has been removed from the annealing process by automatic control, not only of the chamber temperature but also of the charge itself. The two recording control pyrometers keep the furnace chamber temperature constant at any temperature from 1200 to 1350 deg. F., depending on the temperature required for the material treated. A recording pyrometer with its thermocouple in the charge indicates the temperature at the center of the charge.

About 10 to 12 charges of from 1 to 1½ tons of brass each are annealed per 12 hour day. Depending on the weight of the charge the time varies from ¾ to 1½ hours. The furnace cools from 1300 deg. F. to 1050 deg. F. after a nightly shut down with a cold charge placed in the furnace after the last charge of the previous day has been withdrawn and the power cut off. In the morning it acquires 1300 deg. in 30 minutes. When a charge has been withdrawn, only 10 to 15 minutes are required to regain the temperature at 1300 deg. From this it can be seen that the operation of the furnace is very rapid.

The power consumption averages 110 kw. hours per ton of brass annealed or a production of 18.2 lbs. of brass per kwh. The cost of electric power exceeds the previous cost of fuel by only 7½ per cent,

FIG. 14

the saving in labor and time in the subsequent operations bringing the total cost of operation of the electric furnace below that of the old fuel fired furnace.

Application of Electric Heat to Annealing and Hardening Wire.

The usual process in hardening wire is to heat in a lead bath at a temperature of 1600 to 180 deg. F. and to quench in a bath of oil at about 710 deg. F. The lead bath is contained in a cast iron box which in a fuel fired furnace is heated directly by the flame. This uneven distribution results in a very short life of the container which in many cases burns through allowing the lead to run out. This causes the loss of a considerable amount of lead and a more important loss of time in repairing the furnace. The temperature cannot be accurately controlled and the product cannot be made uniform in quality.

This process is very satisfactorily carried out in the electric furnace. The following report of the installation at the Stewart Hartsborne Company plant describes the operation of the electric furnace.

Continuous electric furnaces are used by the Stewart Hartshorne Company for annealing and hardening

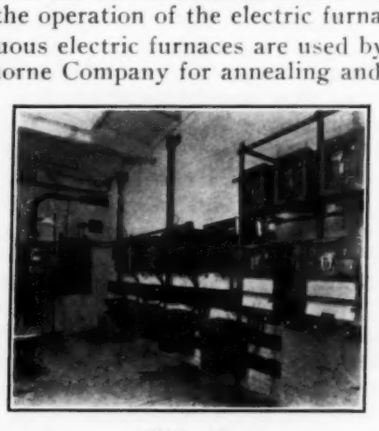


FIG. 15

steel wire used for making small springs. The material ranges in thickness from .032 in. to .077 in. From 10 to 32 strands can be treated continuously, depending on the size of each strand and at a speed of from 32 ft. per minute to 48 ft. per minute.

The wire is first run through a nickel chronium tube in the electrically heated air furnace. The hard-

ening furnace is 18 ft. long and divided into three sections and the temperature of each section is automatically controlled. The first two sections are maintained at 1800 deg. F. and the exit section at 1650 deg. F. Upon leaving the air hardening furnace the wire is quenched in a bath of oil which is kept on continual circulation. After quenching, the wire is tempered in a lead bath at a temperature of 710 deg. F.

The lead bath is electrically heated and the temperature manually controlled. Figs. 13 and 14 show the furnace in operation.

The old method of doing this work was by means of cast iron retorts heated by producer gas, the hardening being done in lead. This method has been in use many years but was very unsatisfactory in that temperatures could not be controlled closer than 25 deg. F. and further, the gas heated pots burned out 15 times a year with consequent loss of production and cost of rebuilding.

The electric furnace takes up about 50 per cent less floor space than the old gas heated furnaces and has twice the production in other words, one electric furnace does the work of two gas heated furnaces. The electric furnace has been in operation for five months running continuously 24 hours a day without any sign of needed repairs; in this period the gas furnace would be down about six times.

The control of the electric furnace is practically constant, showing not greater than 3 deg. F., rejections being reduced to a minimum, due to this feature, and the even distribution of heat.

Cost of operation is decidedly in favor of the electric furnace, as can be seen from table below:

Cost per 100 lbs.	Labor and Fuel	Fuel
Gas furnace	$.853	$.381
Electric furnace..	.53	.26

This shows a saving of $.328 per 100 lbs. by use of the electric furnace, basing these costs on the $.02 rate per kwh.

In addition to the saving in power, the ease of operation and improved working conditions are advantages in favor of the electric furnace.

Fig. 15 shows transformer and control room. In Fig. 14 note gas furnace in foreground which was displaced by the electric furnace.

Low Temperature Ovens.

As previously stated in the report, heating units operating at temperatures below 1000 deg. F. are classed as ovens. This class of heating equipment is used to advantage in iron and steel plants in such processes as the following:

Drawing the temper of tool steel hardened in a medium temperature furnace. (The use of a low temperature oven for this purpose is described in Mr. Jelly's article already referred to.)

Baking of sand cores used in castings.
Baking of motor armatures.
Enamelling.

Under what may be classed as special applications, there are the following:

Electric steam boilers.
Sheet mill roll heaters.
Heating of metal pattern plates.
Air heaters.

Applications of Low Temperature Heating.

A very important application of the low temperature oven in foundries is in the baking of cores, used for castings. One of the most serious troubles met with in foundries, causing defective castings is the non-uniformity in the quality of the cores. An overbaked or burned core will crumble and alter the shape of the castings. Castings with blow-holes are caused by under-baked cores. With the accurate control of temperature possible in the electric furnace, the trouble due to defective cores can be largely eliminated.

Another use of low temperature heating in the foundry is in the heating of metal pattern plates.

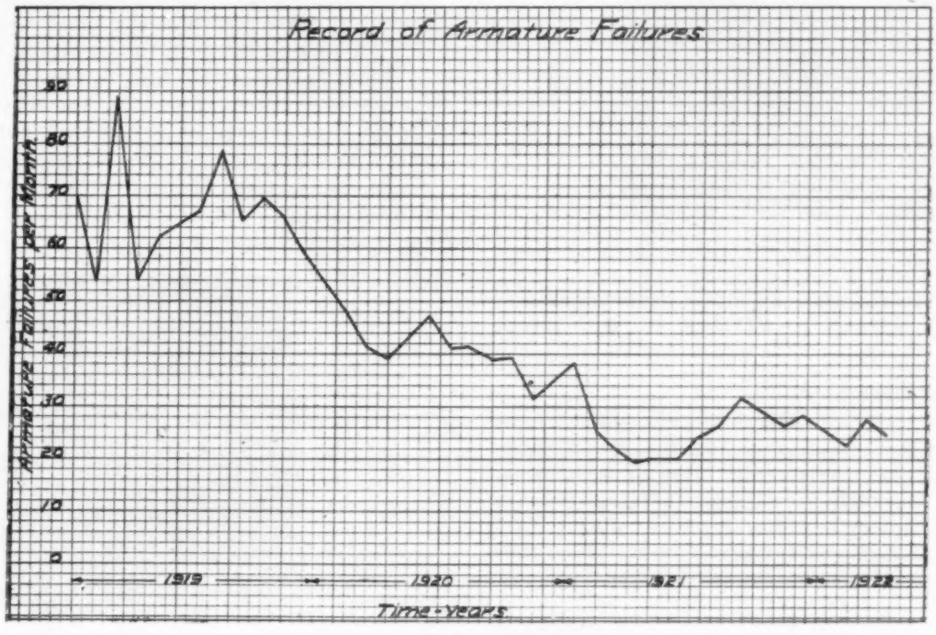


FIG. 16

When moist molding sand is rammed up around a cold metal pattern a thin film of moisture collects on the pattern so that when it is withdrawn from the mold there is a tendency for some of the sand to cling to the mold. Steel clad heaters are used by the U. S.

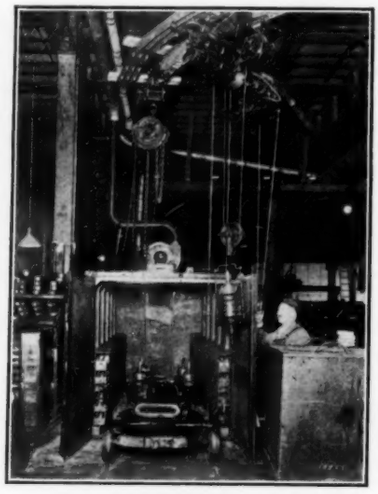


FIG. 17

Radiator Company to keep the metal pattern plate at a temperature of 90 deg. to 100 deg. F., with excellent results.

Baking of Motor Armature.

In the electric railway field the baking of rewound motor armatures has resulted in a materially increased life of the armatures in service. An increase of 75 per cent in the average life is not uncommon. The following curve shows how the armature failures decreased on a typical electric railway installation after the dipping and baking of rewound armatures was adopted in 1919.

The similarity of mill and crane type motors to railway motors and the service to which they are sub-

FIG. 18. — *Shows the oven installed in the repair shop.*

jected would indicate that the adoption of the practice in steel mill repair shops would be amply justified. A furnace capable of handling eight armatures per bake can be installed at an approximate cost of $1200 to $1400. Fig. 17 shows an oven in which is being treated armatures and field coils. Baking the armatures seals up the insulation which may have been cracked during winding, excludes the moisture and prevents deterioration of the insulation. Few steel plants have tried the baking of rewound armatures. The Niles Bement Pond Company, however, is using an electric oven for baking motor armatures in their plant with gratifying results, as indicated by the following statements of their electrical engineer, Mr. Seymour.

Any manufacturing concern using a large number of electric motors finds that despite careful handling the coils in the motors work loose and eventually need replacing.

The Niles Bement Pond Company found that they could best take care of such routing repair work in their own shops. Consequently they have in their electrical department of the pond works at Plainfield, N. J., a section devoted to the repair of motors.

The equipment for this work is very simple, consisting merely of apparatus for forming coils, racks for holding armatures, while they are being repaired, and a Westinghouse K-30 electric oven.

In some cases, coils are replaced; in others the rotors are just varnished and baked. This oven has been in operation about two years and up to the

FIG. 19

present time there have been no maintenance charges against it.

Before the electric oven was installed, a coke fired oven was used for baking the coils and armatures. This oven was used also for baking cores in the foundry, and was located nearly a quarter of a mile from the electrical repair shop. The electrical equipment to be baked was prepared in the repair shop and carried to the oven. In order to keep the temperature reasonably near the proper point, it was necessary to keep the doors partly open.

It is easy to see that it was almost impossible to obtain anything like uniform results under such conditions. Sometimes, when the men returned for the pieces they had left to bake, they would find that someone had closed the doors, thus running the temperature up and ruining everything they had put in. On other occasions they would find the doors wide open and the varnish not nearly dry.

Since the electric oven has been installed, all this has been done away with. Due to its compact construction efficient insulation and the absence of dust and gases, it is possible to place it in the repair shop, where it is most handly.

Now, when coils or armatures are ready for baking they are placed on racks in the oven, the doors closed and the current turned on. Automatic control

keeps the temperature at the right point and when the time of baking is up, the parts are removed, perfectly baked. The surface is not covered with dirt and sand, as was the case when the old oven was used, but is clean and smooth. There is no more underbaking or overbaking, we can depend upon uniform results.

Another use has been discovered for this oven. We were not satisfied that the mixture we were using for our cores was the best. It was decided to test various core mixtures and see what would give best results. In order that these tests are worth anything, it was necessary that the test cores be all baked under the same conditions which we could control. We naturally turned to the electric oven for this work and are satisfied that the various sample cores are baked according to our wishes.

We are well pleased with the results we are getting from our electric oven. It is convenient and dependable and easy to operate.

Enamelling.

The low temperature oven has proven the ideal method for baking enamel on steel parts, such as automobile fenders and bodies. With the electric oven, a better finish is obtained, due to the more uniform application of the heat and there is less danger of explo-

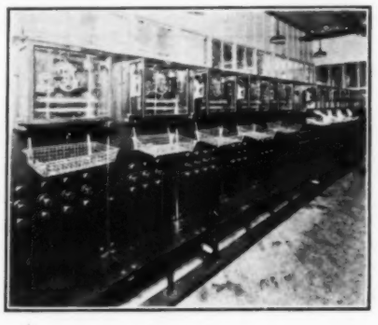


FIG. 20

sion resulting from the volatile matter in the varnish or enamel than with fuel fired ovens. Ovens for this class of work are usually of the continuous type. Fig. 19 shows the construction of continuous conveyor type enamelling oven while Fig. 20 shows the regulating equipment used to maintain the various sections of the ovens at the correct temperature. This equipment is installed in an automobile factory in Detroit.

Electric Steam Boilers.

One argument that has been advanced against the electrification of steel mills is that it is necessary to have a steam system for heating. Although heating an office building by electricity may appear to be uneconomical when considered by itself, it may prove to be the most economical method from the point of view of a large plant.

The main office building of the Steelton plant of the Bethlehem Steel Company is located at a distance from the boiler plant from which it receives steam for the heating system. The losses in the steam line are, of course, large compared to the losses in an electrical system.

A couple of years ago, heating of the office building was considered as a means of reducing the cost and relieving the boiler plant of this part of the load. It was found that there would be little difference in cost between the electric system and steam system but, since the steam system was already installed, the electric heating system was not tried out. The plan for electrically heating the building was to install in the building 2400 kw. tubular type water boiler with

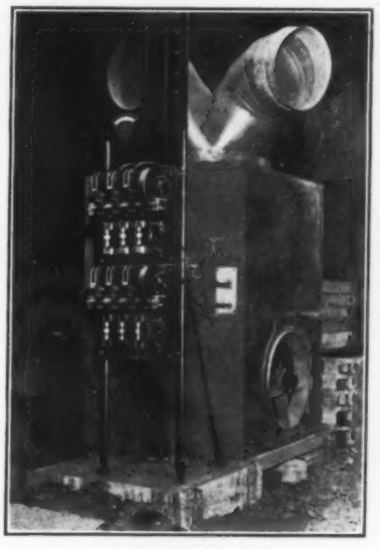


FIG. 21

metallic resistors in the tubes to heat the water in a 2,560 cu. ft. storage tank. The water stored in the tank would circulate through the coils of the air heating radiators. The purpose of the storage tanks was to provide a means of storing heat during peak load periods, using a relay to cut off the heating system when the load reached a certain value. The storage capacity figured on was sufficient to carry the system for 2½ hours with no power being delivered to the boilers.

Electric air heaters are used by the Keokuk Steel Castings Company of Keokuk, Iowa, for keeping the 164 x 92 ft. foundry warm during the night. Fig.

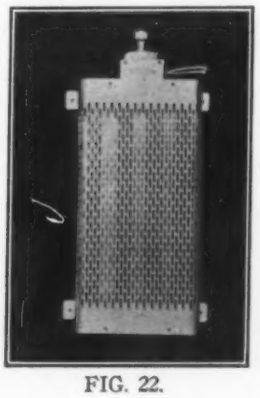


FIG. 22.

21 shows one of the units. The cheap power available from the hydro-electric plant on the Mississippi River at this point makes electric heating the most economical method.

Small electric air heaters such as illustrated in Fig. 22 contribute much to the comfort and efficincy of the operators in outdoor crane cabs.

Sheet Mill Roll Heaters.

A recent important development in the low temperature heating field is the sheet mill electric roll heater. The following article by Mr. Gordan Fox describes the heater and its application:

Electric preheating of the finishing rolls of sheet and tin mills is a new development in low temperature electric heating. The marked benefits afforded and the pronounced superiority over any previous heating methods are rapidly establishing this as a distinct improvement in the art of rolling sheets. The electric roll heater fills a long-felt need in an admirable manner.

The device comprises two frames each carrying two flexible cylindrical sectors. The frames are arranged to clamp a pair of rolls in place in their housings. The cylindrical sectors, which carry the heating elements on their internal surfaces, fit snugly to the rolls. Due to the flexible feature and by means of takeup devices, the heaters will fit rolls varying in diameter due to dressing. Each half heater is provided with leads with knuckle-joint disconnecting terminals for quick connection to cables extending to a switch ordinarily mounted on a column near the mill. The appearance of a roll heater is shown in Fig. 23.

The heaters are ordinarily handled by a crane. They are provided with swing bolts and ratchet wrenches making their application and removal easy and rapid. About five minutes are required to remove and store a heater and to rig a mill with the fore plates and rest bars ready for rolling. It has been found that, after the heaters are removed, the rolls drop in temperature about one deg. F. per minute, this small loss having no apparent bearing on the results obtained.

The manner and extent of heating of the rolls is best shown by Fig. 24, which gives the results of tests on two 28 in. x 44 in. mills equipped with 28 in. x 36 in. heaters. In one case, the heating period was nine hours and the final temperature at the center of the roll face was 540 deg. F. In the other case, a temperature of 617 deg. F. was obtained after a period of 12 hours. A moderate rate of heat application has been selected to approximate heating by rolling and to minimize expansion strains. It has been found entirely possible to bring the rolls to a temperature of 750 deg. F. but no benefit is apparent over results obtained with rolls at 600 deg.

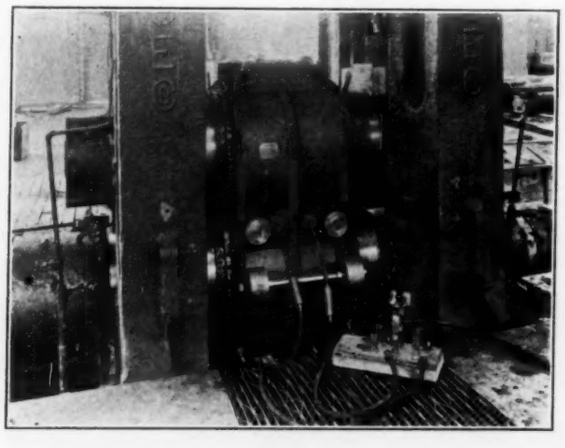
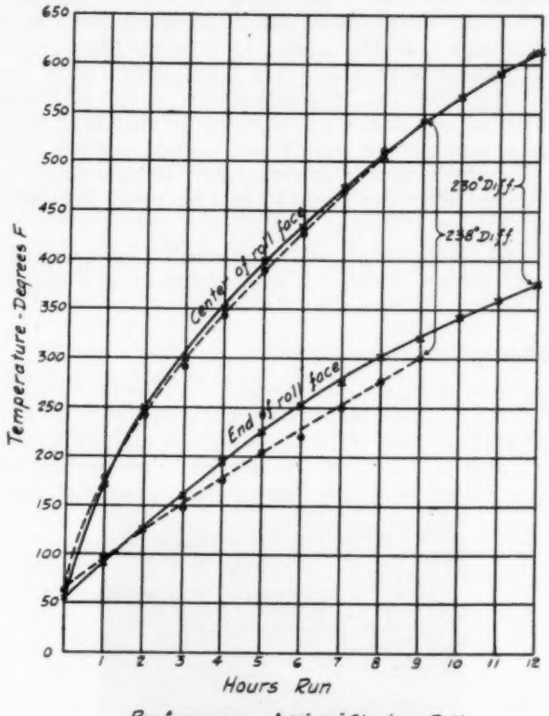


FIG. 23

It will be noted that approximately 230 deg. temperature difference exists between the center and the end of the roll face at the end of the heating period. This difference corresponds closely with rolling conditions and approximates the difference necessary to remove the cross from the rolls. The design of the heating elements has been governed to secure this result. It has been found entirely possible to warm up to a "full mill" with the electric heaters but ordinarly the mill is a trifle hollow at starting with 2 in. or 3 in. fish-tails on full width sheets.



Performance of 28"x36" Electric Roll Heater on 28"x44" Rolls

FIG. 24

The uniformity of heating is excellent. Although the entire periphery of the rolls is not directly covered by the heaters, the flow of heat is sufficiently rapid so that there is no appreciable variation nor the least corrugation nor distortion of the rolls. In an endeavor to detect any "out-of-round" condition, longitudinal strips have been cut from the first packs through the rolls. These strips were calipered for gauge and found to be as uniform on the first pack as on any subsequent pack.

An interesting test was run on a 28 in. roll which had three holes drilled radially inward near the center of the roll face. These holes were 4 in, 10 in. and 14 in. in depth. Temperatures taken while warming up this roll electrically indicate that the interior of the roll heats up substantially as rapidly as does the surface.

Electric preheating gives temperatures much in excess of those attained by any other method of preheating other than the use of "warming-up" iron. Moreover, it is a definite method as contrasted with rather haphazard results obtainable with gas flame, exhaust gases, steam or hot water. This fact is brought out in Fig 24, showing the close duplication of performance of two similar heaters on similar mills but

in two different plants. Since electric preheating affords a definite result, the furnaces may be charged with no hestitation as to the condition of the rolls to handle the order charged.

The practical results obtained with electric preheating are measured by their performance in the several plants now using them. These plants now find it unnecessary, in fact rather undesirable, to roll narrow iron on a mill which has been electrically preheated. Many independent rollers have pronounced the rolls to be practically in mid-week condition at the beginning of the first turn. At one plant, 30 gauge, 36 in. wide, 96 in. long sheets are frequently rolled on a 44 in. mill with no preliminary orders and no extra passes and this mill has rolled 30 in. x 36 in. x 120 in. sheets in the first charge with entire success. This mill has made some excellent tonnages on the first turn. It may be definitely stated that warming-up iron may be dispensed with when rolls are electrically preheated and the tonnage on the first turn may be as high as on any other turn.

The amount of electric power consumed in heating the rolls depends upon their size, initial and final temperatures and the period of heating, but is ordinarily on the order of 500 to 750 kwh. per application. At one cent per kwh., the cost is thus about $5.00 to $7.50 per application.

As the heaters are applied to the standing rolls, no power is required to turn over the mill. The power required to turn over one pair of rolls is nearly as much as the input to one electric roll heater. The power required to turn over a cold mill and a hot mill is ordinarily more than the input to an electric roll heater. As the mill is standing no attendance is required during the heating period.

To date no roll breakages attributable to warming up have been reported on mills using electric preheaters. A considerable saving due to decrease in roll breakage is indicated but not yet established as a certainty. During the winter months it is recommended that the heater halves be connected in series to give a slow heat during the first hour or two to take out the frost before full heat is applied. This is accomplished by a throw-over switch.

Electric heaters have been frequently applied to rolls in a rack to preheat prior to a mid-week change of rolls, with admirable results. One plant keeps a pair of rolls hot at all times by use of an electric heater thus applied.

Electric Heating with Special Reference to Central Stations

By E. D. SIBLEY*

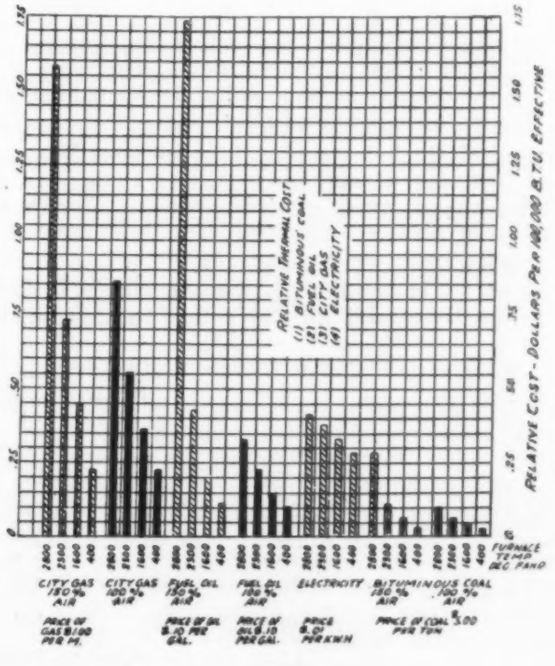
THERE are in the United States today thousands of industrial heating installations, many of them of hundreds of kilowatt capacity and some of thousands of kilowatts. These installations consist of a large number of arc and induction furnaces used for melting and refining steel, brass and copper, also of electric ovens and metallic resistor furnaces.

There are quite a few electric steam generators which are finding a large field in the conversion of seasonable or other excess water power into steam, thus saving the equivalent in coal.

Electric furnaces and ovens are built in a variety of types and in themselves constitute a broad subject of which there will not be an attempt to discuss here.

Heat energy application in this country has been to a certain extent the composite result of promotion and advertisement rather than of engineering. We have had fuel oil advocates, gas burning advocates, powdered coal enthusiasts, fuel oil specialists, etc., but have until recently lacked the competent furnace engineer familiar with all types of furnaces, who could sit as a court of appeal and give unbiased decisions regarding the true economic value of various heat sources for a specific work. To operate with a certain fuel when the operation could be carried out with another fuel more advantageously, is not economy, yet many such cases exist today.

The accompanying chart shows the relative costs of four common sources of heat—coal, gas, fuel oil and electricity, in terms of dollars per 100,000 Btu. used in furnaces and baking ovens. This chart in itself is evidence of the fact that considerations other than Btu. cost determine the true efficiency of thermal processes. If this were not true the electric furnace could not exist, for it could not show the greater



*Plant Supt., Metropolitan Edison Co., Reading, Pa.

over-all economy that it does in many processes today. Neither could the other two fuels compete with bituminous coal, did not the application of fuel oil or gas carry with it inherent advantages that completely outweigh the difference in cost of the Btu. supply. This is the true reason for the use of oil and gas rather than bituminous coal for many thermal processes. For the same reason electric heat is today recognized by competent engineers as the "last word" in carrying through many thermal processes with maximum safety, uniformity and economy.

It will be noted by looking over the chart that the cost of burning fuels varies widely, depending upon the amount of air admitted to the furnace and the resultant combustion; for instance, the cost of city gas for 100,000 Btu. effective rises to double its value with an increase of 50 per cent in air, and such excess percentage of air is by no means rare. Fuel oil likewise increases its cost roughly four times at the same temperature (2800 deg. F.) and same excess air (50 per cent). Thus it is seen to how great an extent the economic operation of the fuel furnace is in the hands of the operator. This handicap does not exist with the electric furnace, where the ratio of conversion from power to heat is 100 per cent perfect, and the operator cannot affect the efficiency of conversion.

It is a matter of no distant time when the use of electric heat for important thermal processes will be adopted with no more hesitation than now occurs when the householder decides in favor of the electric light instead of the gas lamp for his home, even though the cost of current consumed be greater than the cost of gas.

For purposes of analysis, electric heating applications are divided into four groups designated by temperature ranges.

Group I includes applications below 1000 deg. F. The heating elements for most purposes in this group are made of individual units of nickel chromium. The work covered is tempering and finishing of steel parts, japanning, heating of core ovens, and the like.

Group II includes applications between 1000 deg. F. and 2000 deg. F., and requires a special unit of heavier nickel chromium, which is rolled into special shapes and requires special hangers. The work covered by this group is principally the annealing and heat treating of carbon and alloy steel.

Group III includes applications between 1800 deg. F. and 3000 deg. F. and has a heating element of the muffled-arc type, which generally consists of a trough of carbon or similar conductor. The work covered is brass and bronze melting.

Group IV is handled by the electric arc furnace for melting steel and its alloys, and the heat of the electric arc is limited only by the ability of obtaining refractory substances to withstand the heat.

The surveys and estimates made by the Industrial Heating Committee of one of our large manufacturers indicate that there is in this country today a connected industrial heating load of approximately 1,250,000 kw., which I am informed is roughly one-tenth of the total connected power load. Of this amount, 1,000,000 kw. is connected to central station lines, drawing therefrom an annual energy consumption of 2,000,000 kwh. and producing an annual revenue of $40,000,000.

The following tabulation shows these totals separated according to the different classes:

	Kw. Installed	Annual Consumption kwh.	Revenue Produced
Steel melting furnaces...	225,000	505,000,000	$ 6,200,000
Brass melting furnaces...	95,000	290,000,000	4,700,000
Heat treating furnaces...	85,000	220,000,000	3,900,000
Industrial ovens	200,000	380,000,000	6,500,000
Bread baking and commercial cooking	100,000	109,000,000	2,700,000
Welding	55,000	25,000,000	880,000
Misc. small units.....	325,000	590,000,000	14,800,000
Totals.....	1,085,000	2,119,000,000	$39,680,000

This tabulation shows that steel melting furnaces account for almost one-fourth of this connected load and annual consumption, and industrial ovens about one-fifth, but the multitude of small heating units in total constitute about one-third of the connected load, somewhat less than one-third of the annual consumption, and about 37 per cent of the annual revenue.

The foregoing indicates the present development of electric heating. It seems that no general estimate of the possibilities in this business can be made with any degree of accuracy covering the entire country until local surveys are completed by the individual central stations, but it has been predicted that the heating load will ultimately be two and one-half times the motor load.

The manufacturers of electric heating equipment have unquestionably devoted tremendously large amounts of time, effort and money to the development of equipment which will achieve the results required, with the result that there is now on the market a sufficient amount of standard apparatus, and a sufficient amount of standard applications have been developed to warrant an investigation by any manufacturer who is considering a heating application, small or large. For the most part, electric heating load is very desirable from the operating standpoint of the central station, and is often more profitable than many of the loads now served.

A great many central stations have well defined

KILOWATT CAPACITY OF INDUSTRIAL HEATING APPARATUS SOLD IN PAST FIVE YEARS BY EIGHTEEN MANUFACTURERS

Year	Heat Treat Furnaces	Commercial Cooking Equipment	Melting Furnaces Brass	Melting Furnaces Steel	Ind. Ovens	Misc.	Welders	Total
1919	6,770	20,000	13,950	19,935	50,450	44,100	6,000	161,205
1920	13,050	19,150	17,050	18,020	33,450	66,100	17,000	183,820
1921	10,218	12,200	14,455	21,500	23,450	41,600	8,000	131,423
1922	15,161	15,300	19,275	26,330	27,450	56,600	10,000	170,116
1923	20,202	18,500	23,435	15,723	26,460	66,500	13,000	183,820
Total.....	65,401	85,150	88,165	101,508	161,260	274,900	54,000	830,384

(This table furnished by Industrial Heating Committee of N. E. L. A.)

commercial organizations, which include a man sufficiently well informed to determine the possibilities of electric heat in any general application. Every industrial heating proposition of any consequence requires special treatment and study, not only by the manufacturer of the equipment, but also by all other parties connected with the operation.

Our own company at the present time has an industrial electric heating load of approximately 12,000 kw. This load is composed of 11,320 kw. in steel furnaces, 90 per cent power factor, 24 hour a day operation; a 115-kw. japanning oven, unity power factor, 10 hour a day load; a 65-kw. induction brass furnace, 85 per cent power factor, 10 hour a day load; a 55-kw. carbonizing furnace, unity power factor, 10 hour a day load; 3 core baking ovens, unity power factor, 10 hour a day load; two 25-kw. bread baking ovens, unity power factor, 10 hour a day load, and a number of small heating applications which are mostly unity power factor loads.

Small heating appliances used in homes are coming on our lines very rapidly. It is interesting to note that our load due to flat irons being used in homes is between 1,500 and 2,000 kw. Our records show this to be apparent on Tuesday mornings between the hours of 10 and 11 o'clock.

From the foregoing it is apparent that steel furnaces form a very large part of our heating load, and the fact that the majority of this is for 24-hour operation makes it very desirable, from the operating standpoint as well as the financial return.

The Carpenter Steel Company of Reading, who have the largest single electrical heating load on our system, are also our largest customer. This company, a pioneer in the use of electric steel furnaces in this locality, is due a great deal of credit because of their rapid development and their ability to operate furnaces with great efficiency. They have four large steel furnaces handled by three 750-kva. transformers each. These transformers step the voltage from 13,200 to 110. From observations and tests the load on each phase is very nearly balanced, which helps efficient and satisfactory operation from our own as well as the Carpenter Steel Company's standpoint.

The kwh. consumption of this company constitutes about 15 per cent of the total output of our Reading power plant, and we hope that as we add more load the Carpenter Steel Company's percentage of our output will at least remain the same.

The balance of the load of this type, while only for 10 hour a day operation, is principally unity power factor, which makes it also a desirable load.

It is impractical to draw a curve showing the steps by which our industrial heating load has been built up, because the steel furnaces were put on our lines just before and during the war. The balance of the industrial load has been placed on our lines during the last two years, as a result of developments made by manufacturers and also our company's efforts to educate different customers as to the advantages and economies of electric heating. Our company, like a good many other central stations, has installed an electric heating department as a part of the power sales department, which is now making a survey as to possibilities and applications in its territory. This in itself is evidence of the desirability of this load to the central station, and as installations of various types are made, we feel that the interest of industrialists will increase to the point where every heating application will be investigated with a view to determining the economics of electric heat.

Our power plant has increased its output approximately 700 per cent since 1911 and our industrial load is rapidly increasing. We estimate that our possible industrial heating load will be 30,000 kw., which will be absorbed in the natural growth of our power facilities. This is due mainly to the number and diversity of the industries in the Reading Division, which have been growing more or less steadily, and we believe will continue to do so.

We are very pleased with results already obtained with the heating load with which we come in contact, and are anxious to give any assistance possible to interested parties. We endeavor to keep up-to-date literature and engineering information on electric heating in our files, and have gone to the extent of visiting plants in other sections of the country in order to obtain accurate data for the benefit of possible users.

The references above stated present only a few of the applications which may interest the iron and steel man. There are electrical heating applications for nearly every business and industry, both small and large. Finally it may be said that due to the efforts of the last few years, industrial electric heating, for which so much has been hoped in the past, is now an accomplished fact and is firmly established on a sound basis.

Adjustable Speed Drives for Rolling Mills

By L. A. UMANSKY*

The Need for Adjustable Speed Drives

THE success of electric drives for rolling mills of every kind and size is due to the efforts of electrical engineers to design and apply mill motors whose performance would not only alone equal, but would excel the performance of steam drives. Electric power rolls steel better and cheaper than steam; it reduces delays and increases reliability; it gives the mill operators an exact knowledge of mill performance. With these advantages so readily recognized, it became a duty of the electrical profession at large to keep on solving any additional rolling mill problems which had been previously solved—inefficiently, to be sure—by steam drives.

For instance, the mill operators were accustomed to adjust the speed of the driving steam engine whenever the size of the rolled sections was materially changed; this speed adjustment was easily accomplished by simply changing the setting of the gover-

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nor. There are a good many reasons why most of the mills with a diversified line of products should have several rolling speeds. A uniform average speed may be a poor compromise; the output of lighter sections may be curtailed; they will be rolled at a lower temperature and the amount of power per ton of steel rolled will be appreciably higher; some small sections would be so cold in the finishing passes that the quality of the product would be impaired. Likewise, troubles may be expected with heavier sections; the compromise speed may be too high for the rolls to get a good hold on the metal when the steel enters the mill. It might happen that, by selecting a constant speed drive for such mill, the extreme light and heavy sections could not be rolled on it at all, and the work will have to be passed to other mills, if such are available.

Thus the desire of mill departments to have adjustable speed drives is legitimate and just. Electrical engineers were asked: Can you give us a drive of that sort? The electrical profession was put up against this problem and found that it was—and is—quite a hard problem, indeed; the difficulties were not so much of an engineering as of an economical character.

It should be stated at the very beginning, that **any** electrical adjustable speed drive, regardless of the speed regulating system employed, costs appreciably more than a constant speed drive. With a.c. universally used for power generation and distribution in almost every steel plant, the use of this power for driving the rolling mills, with as little transformation as possible, is extremely advantageous. Furthermore, we all know the attractive features of the induction motors, extreme simplicity of construction, ruggedness, and ability to take heavy overloads; they are the least expensive machines per hp., both from the standpoint of first and of maintenance costs. But the induction motor is inherently a constant speed machine; as soon as we want to obtain any speed regulation we must make a radical departure from simplicity; we must either add to the induction motor a few more, less simple machines, or else convert the a.c. power to d.c. and drive the mills by d.c. motors. Either scheme introduces the use of commutator machines; in fact, the brief review, to be given presently, will show that no truly adjustable speed drive of **any** kind is feasible without an a.c. or d.c. commutator. To be sure, we know how to build good commutators; they certainly are now more reliable and less apt to cause trouble than, say, the valves of a steam engine. But the steel mills, with dirt, scale and 24-hours-a-day operation, are certainly not the best places in which to keep the commutators in good shape; besides, a commutator machine costs more than the induction motor. For this reason any departure from the constant speed principle radically changes the cost of the drive; very seldom is this increase of cost less than 50 per cent, not infrequently it approaches 100 per cent, depending, of course, on the speed range required and on the type of system that is employed. This fundamental fact should not be lost sight of whenever the question of steel mill drives comes up. And, certainly, the purchasing departments are fully aware of this!

But there is another, broader point of view. After all, the rolling mills are not built merely to provide a field for application of electric motors, nor for giving an opportunity to buy the cheapest kind of drives. **The primary purpose of any mill is to roll steel—the more of it, the better.** There is no use comparing costs of several systems of electric drives, without checking their effect on the mill output; the most economical drive is not the one that has the lowest cost, **but the one that costs the least per ton of steel rolled.**

Take for instance the mill layout shown on Fig. 1. A large mill of similar character is now under construction in the Pittsburgh district. Such mill may

FIG. 1—*Elementary layout of a modern merchant mill, rolling large tonnages of very much diversified products. Note the principle of individual drives employed, and the very wide speed range. This enables the mill to do the work of two or three less flexible mills.*

be capable of rolling exceptionally large tonnages of such diversified products as 3x3x⅛ in. angles, 10x¾ in. skelp or 3x.065 in. strip, to mention only few out of many sections. In order to take care of such special requirements, it was essential to provide individual drives for practically every stand and to give exceptionally wide speed range to each of the several drives. Naturally, the electric equipment for this mill is relatively expensive; but without this flexibility of speed adjustment two or three mills would be required to produce the output of this single mill. Now the cost of electrical equipment is only a part of the cost of the whole mill; **one is truly wise who pays more for a part to save on the whole.**

Full account is taken of the existence of a number of mills—mostly old ones, built in steam engine days—which mills roll varied products, but in such limited quantities that very little is **actually** gained by increasing the **potential** tonnage capacity of the mill. Sometimes a constant speed or, possibly, a two-speed drive will fully meet the requirements of such a mill; a more elaborate electrical equipment may be found to be a luxury, not fully justified.

Thus the question of advantages to be derived from the use of an adjustable speed drive, and of the necessary speed range and capacity, requires the closest co-operation of the mill and of the electrical departments; without combining the knowledge of both, proper solution may not be found. A partition between the motor room and the mill is a good investment; but no **mental** partition should exist between the two organizations.

Capacity of the Adjustable Speed Drives Throughout Their Speed Range.

Granting that a given mill requires an adjustable speed drive, and that the necessary speed range is determined, our next problem will be to find out the required capacity of the drive at its different speeds.

It is absolutely useless to speculate in a general way whether the horsepower available at the minimum speed should be the same as it is at the top speed, or whether the horsepower should vary in proportion to the speed. Nowadays, when we know so much more regarding the power required to roll steel **than we knew some years before, guess work and ar-**

bitrary speculation should be dispensed with, and sound engineering calculations substituted.

Take for instance the case of a merchant mill, shown on Fig. 2 Rolling schedules were studied and power observations were made for the minimum, average and maximum speeds, rolling in each case the hardest sections. The result of these tests and calculations are shown on Fig. 2.

You will note in each case the values of the maximum load, and—most important—the values of the mean effective heating load (root mean square—RMS—value) which directly indicates the required contin-

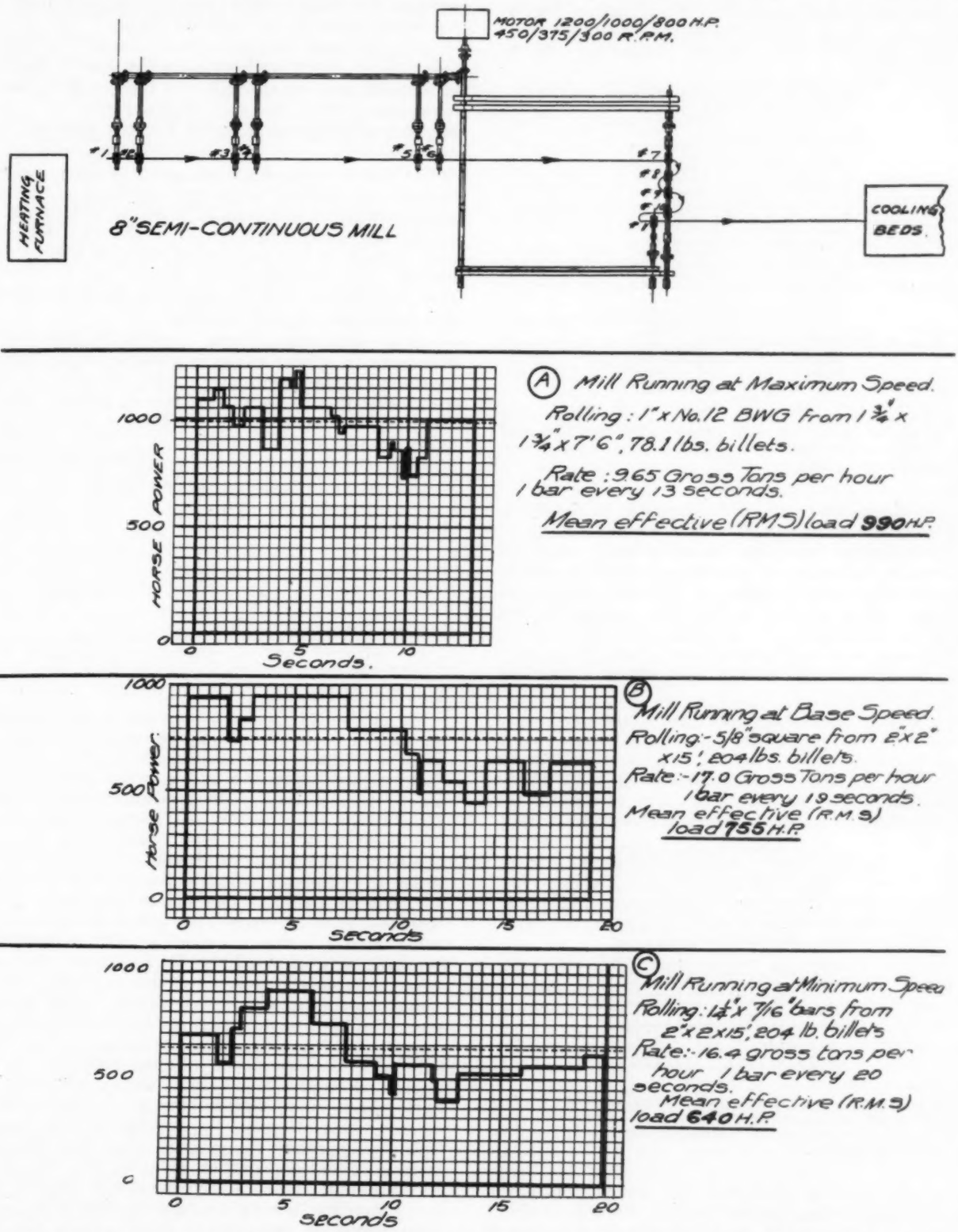

FIG. 2—*Rolling duty cycles for different operating speeds of the 8-in. semi-continuous merchant mill, shown in the upper part. The horsepower load is increased with the speed.*

uous capacity of the drive at different speeds. It will be readily observed that **for this mill** the horsepower requirements **increase** very appreciably with the speed. (See Fig. 3.) The choice of a constant torque drive, i. e., with increased horsepower at increased speed) was fully justified.

On the other hand, conditions illustrated on Fig. 4 are different. Tests were made on the finishing stand of a 16-in. hot strip mill. Points plotted on Fig. 4

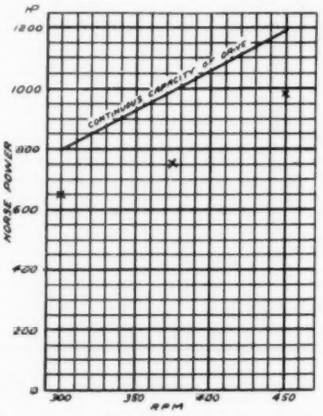

FIG. 3—*The points marked with (x) indicate the loads imposed on the motor driving the mill shown on Fig. 2. The solid line represents the continuous capacity of the driving motor at different operating speeds.*

show the horsepower demands imposed on the drive at different operating speeds; tests covered rolling of a large variety of sections, the wider strip requiring lower speed, in order to maintain a good finish of steel; the wide strip requires an increased torque, as the elongation given the metal is not reduced in this case proportionally to the increase of width. Thus, Fig. 4 shows that a constant horsepower drive more nearly fits **this particular mill** than would a constant torque equipment.

It is generally true that the larger sections are rolled at a reduced mill speed; but it is **wrong** to draw from this fact the conclusion that the large sections **always** require an increased torque of the driving motor. This may or may not be the case, depending entirely on the type of rolling. If, for instance, we consider a mer-

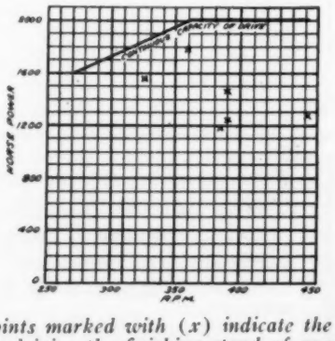

FIG. 4—*The points marked with (x) indicate the loads imposed on the motor driving the finishing stand of one hot-strip mill; the solid line represents the continuous capacity of the drive at different speeds.*

chant mill, we will often find that the section of the original billet or bar, as delivered to the mill, is about the same for the entire range of mill products; it is evident that under circumstances, actually less torque will be required **per bar** when finishing larger sections at the minimum speed than when rolling smaller sections at the top speed. It is also the case with many merchant mills that there are less bars in the mill simultaneously when large sections are rolled, for the simple reason that the heating furnace limits then the tonnage; thus, even when the torque **per bar** is not smaller, the total torque imposed on such mill need not be increased at the reduced speed.

It is trusted that no other conclusions will be drawn from the above reasoning but one: **fit the drive to the mill, and not the mill to a type of drive favored for reasons other than mill requirements.**

Systems of Adjustable Speed Electric Drivers.

Thus far we have considered the question of mill drives rather from the standpoint of mill operators, and not as electrical engineers; we have outlined the procedure to be followed, in order to determine, first of all, the speed range and then the capacity at the mill spindle. Let us assume that all this is determined. The problem now before us, as electrical men, is: **What kind of apparatus shall we install at the motor side of mill coupling?**

It is both natural and reasonable for electrical engineers to adhere as far as possible to the "old reliable" induction motor and to try to make its speed adjustable in some way. It is well known what determines the speed of an induction motor; if, for instance, the supply frequency is f=60 cycle, and the machine is wound for 2p=12 poles, then the synchronous or the no-load speed will be, in rpm:

$$n = \frac{60 \times f}{p} = \qquad (1)$$

$$= \frac{60 \times 60}{6} = 600 \text{ rpm.}$$

The full load speed will be, of course, somewhat lower.

Two Speed Drives.

If we could by some means and at will change the number of poles for which the motor is wound then we would change the speed accordingly. This pole-changing operation can and is being done. Unfortunately the method is jerky and unflexible. When the ratio of the high to the low speeds is 2:1, then we can build a two-speed motor with only one set of windings, bring out six leads and by reconnecting them by means of a switch make the motor, say, either a 12-pole or a 24-pole machine, and let it run either at 600 rpm. or at 300 rpm. But when the speed ratio is other than 2:1, the two-speed operation requires two separate sets of windings in the stator and in the rotor, only one of each is working at a time, the other being then so much dead material. The motor becomes bulkier, more expensive and has a lower power factor. No more than two operating speeds are usually provided by means of pole-changing of a mill motor. Roughly, a two-speed motor, with a 2:1 speed ratio, costs 30 to 40 per cent more than a constant speed motor designed to operate at the maximum speed only; when the ratio is other than 2:1, the increase in cost approaches 50 to 60 per cent or more. It should be remembered that all two-speed motors are inherently constant torque machines; if the same horsepower is required at both speeds, this simply means that the motor should be built larger and will **be under-rated at its maximum speed.**

For certain small mills, two-speed drives are quite satisfactory when a more flexible but more expensive drive may not be justified by the limited mill tonnage. Two-speed motors do not belong, strictly speaking, to the class of adjustable speed drives. This name should properly belong to such equipments, which give the operator the choice of not only the maximum and the minimum speeds, but of a number of intermediate points as well.

Speed Control By Secondary Resistance.

When we introduce resistance in the secondary of an induction motor and impose a load, the motor slows down the more so, the larger is the load and the greater is the added resistance. It is simple to understand the reason for this performance:

To overcome the imposed load, the motor should develop a corresponding torque; the torque of **any** electric motor is proportional to the product of the magnetic flux set-in by one member of the machine, say, stator and the current, flowing in the windings of the other of the two members, say, rotor. This is true of a d.c. motor, and is equally true of an induction motor. In this machine the flux is usually set-in by exciting the primary or stator winding; everyone knows that this is a revolving flux rotating with a synchronous speed depending on the frequency and number of poles. When the rotor runs also at synchronous speed, its winding does not cut the flux, and no current flows therefore through this winding; without current, the motor does not develop any torque at all. If the load is imposed the motor, lacking any torque, will, of course, slow down; as soon as its speed is thus dropping below synchronism, the rotor winding begins to cut the magnetic flux, and an emf., being generated in the winding, forces a current to flow in the secondary; this current begins to produce, in conjunction with the flux, a torque. When the slowing-down proceeds far enough, so that enough current flows to produce sufficient torque, the motor speed stabilizes.

All this is characteristic of any induction motor; only ordinarily the secondary resistance is so small that it does not take much of a drop in speed to produce the necessary torque. When an additional resistance is inserted without changing the load the same torque must still be produced; in order to force the same current through the rotor winding with an increased resistance, the motor must slow down more in order to have a proportionally greater emf. generated in its secondary. It is evident that the introduction of a counter-emf., if this could be done, would have the same effect.

The possibility of lowering the speed of an induction motor by introducing secondary resistance is well known to every one; but it is often forgotten that the obtained speed reduction is contingent on the imposed load. Say, for instance, we have forced the induction motor to run with a slip of 25 per cent, i. e., at 75 per cent synchronous speed; double, the load, and the slip will be doubled, i. e., the speed will be only 50 per cent; remove all load—and the motor will return to practically its synchronous speed, because it was only the necessity to generate a secondary current, sufficiently large to overcome the load, that forced the motor speed down. This is plainly a characteristic similar to that of a d.c. motor with a predominating series field. No one will think of equipping the main rolls with such drive after the expected performance is well understood.

But this is not the only shortcoming of the resistance type speed control. Suppose we have reduced the induction motor speed in this manner to 75 per cent; let us read the wattmeter and note that the input to the motor is, say 830 kw.; assuming a motor efficiency of 90 per cent, the motor could have developed at its shaft $\frac{830 \times .90}{.746} = 1{,}000$ hp.; but if we actually measure the shaft output we will find it only 75 per cent of 1,000 hp. = 750 hp.; the other 250 hp. or 25 per cent of the total are gone as waste heat in the secondary resistance. The mechanical or the shaft hp. output is proportional to the speed, while the electrical "output" (in this case, secondary losses) is proportional to the slip; their total should correspond to the total line input, which gives a measure of the motor load. Thus, while it is possible to reduce the induction motor speed by secondary resistance, a very heavy toll is paid for it in the form of large losses.

Desired Type of Control.

Hence the desired type of speed control of an induction motor is clearly defined:

(a) The control should be capable of adjusting the induction motor speed, but once adjusted, this speed should remain substantially constant. We have noted that the secondary resistance acts as a counter-emf. of the value of the IR drop in the resistance, i. e., its value and effect depends on the load. We should therefore find means to provide a counter-emf. that will be independent of the load; then the motor speed will remain constant.

(b) Means should be provided for salvaging the slip energy that goes as waste heat with the resistance speed control. We must put this energy to work on the mill or else should return it to the line, where it is made available for other uses.

When one recalls that the slip energy is of variable frequency and voltage, which are varying with the speed regulation, the real magnitude of the problem becomes apparent.

Constant Horsepower and Constant Torque Drives.

Although many different systems were suggested for this purpose, they all fall in either one of the two classes.

In one case, the slip energy is converted into mechanical power and is thus returned to the shaft of the mill motor. Neglecting transformation losses, we may say, that at all speeds the total power taken from the line is delivered at the mill coupling. Such are the **constant horsepower** drives; as the horsepower is proportioned to the product of torque and speed, it is obvious that these drives have larger torque at low speed and reduced torque at high speed. All drives of this class have an auxiliary motor connected to the mill drive.

In the second case, the slip energy is converted into electrical power of the supply frequency and voltage, and is returned or "pumped" back to the line. As long as the power is not returned mechanically to the mill drive shaft, it is not necessary to attach an auxiliary machine to the main induction motor, and the latter alone drives the mill. As its mechanical hp. output is proportional to the operating speed, the drives of this class are called "constant torque drives."

It is not necessary to study thoroughly any of the numerous systems to decide to which of the two classes it belongs; it is sufficient to glance and note whether the drive is or is not equipped with an auxiliary driving motor. **Presence of such motor means an inherently constant horsepower drive; absence of it means an inherently constant torque equipment.**

There are cases when constant horsepower type drives were given constant torque rating; cases are also known when drives inherently suitable for constant torque operation were designed for "constant-hp." mills. A more careful analysis will unvariably show that in all such cases either one machine or another comprising the drive is larger than necessary at either low or high speed. An "extra size" always means "extra cost," all other things being equal; an extra cost, to be justified, must be offset by savings made possible on other parts of the equipment.

The auxiliary machine for mounting on the drive shaft is less expensive when built for higher speed; hence high-speed geared mill drives are more favorable for the constant horsepower equipment than low-speed drives. With constant torque drives this point is of no material importance.

Practically all known systems may be built of either one of the above types, as we will presently see. **It is absolutely wrong to presume** that, for instance, the Kraemer System should be inherently a constant hp. proposition, while the Scherbius drive should always provide constant torque.

Elementary Cases of Speed Regulation Problems.

The various systems may have a rather complicated theory, if one wants to go to very bottom of things. But the principle of their operation may be

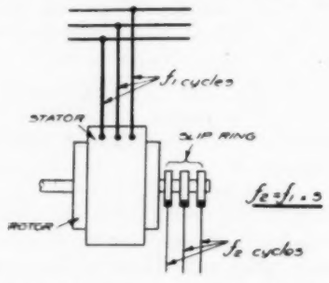

FIG. 5—*Elementary diagram of a slip ring induction motor, showing the relation of the primary and secondary frequencies. (S—slip).*

made fairly clear and comprehensive if we first consider a few elementary cases.

Case I.

This represents a well-known case and is brought here merely to make the story complete.

An induction motor M, Fig. 5, runs on a power supply with a frequency f; its synchronous speed is n rpm., but it runs at n rpm., i. e., with a slip of $s = \frac{n-n}{n}$. The frequency at the slip rings (f_2) is always

$$f_2 = f_1 \times s = f_1 \times \frac{n-n}{n}$$

For instance at standstill the motor speed n =0; the slip s = 1; the secondary frequency f2 = primary frequency f1; the induction motor acts simply as a transformer. When running at synchronism (n1 = n), the slip s = 0, and therefore the secondary frequency f2 = 0. If the primary frequency f1 = 60 cycles and the slip is 25 per cent = .25, then the secondary frequency is f2 = 60 × .25 = 15 cycles. The secondary voltage (across the slip rings) is the highest at standstill and equals zero at synchronism.

Case 2.

Let us take a d.c. generator (see Fig. 6), run it at **any speed,** and excite its fields by a.c. of some frequency f1. What will be the frequency at the brushes? In an ordinary d.c. generator the excitation is also d.c., that is, f1 = 0, and we obtain then d.c. (i. e., zero fre-

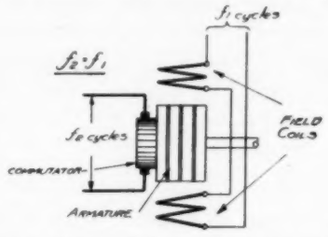

FIG. 6—*Elementary diagram of a commutator machine separately excited from an a.c. circuit; the frequency on the brushes (f_2) is always the same as that of the exciting circuit (f_1).*

quency) on the brushes **at all speeds;** of course, inside the armature we have an alternating current of frequency, depending on the speed, but the commutator always rectifies it. Now, impress, say f1 = 5 cycles on the field; the same frequency will be observed on the brushes, also regardless of speed. In other words, in this case **the brush frequency is always the same as the field excitation frequency.** The voltage is, of course, depending on the speed and the amount of excitation.

Case 3.

We will consider a rotary converter, Fig. 7. If run in a conventional way on power supply of "f1" cycle, it will run at a synchronous speed of n rpm.; for instance, a 4-pole rotary will run at n 750 rpm. on supply of f1 = 25 cycles. We know from everyday practice that we will then obtain d.c. on the commutator brushes, i. e., we will have zero frequency f2 = 0. The d.c. and a.c. voltages are in a fixed proportion to each other. The rotary converter usually runs under its own power; field excitation is needed to create the

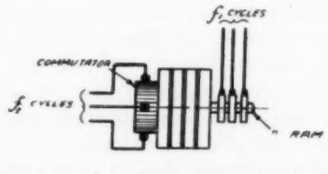

FIG. 7—*The armature of a rotary converter is driven externally, and an a.c. circuit of frequency f1 is applied to the collector rings. The frequency f2 obtainable from the commutator brushes depends on the speed of rotation of the armature.*

necessary small torque to cover the friction, windage and core losses. If we remove the field of the rotary, and will drive it at the same speed from an outside source, it is evident that nothing will change as far as the frequency at the commutator brushes is concerned; at n 750 rpm. we will obtain still f2 = 0 cycle, i. e., d.c.

Assume now that we reduce the speed of rotation of the rotary from n rpm. to a lower value of n rpm.; using the induction motor nomenclature, we will say, that the armature is driven with a "slip" $s = \frac{n-n}{n}$. We will observe that the frequency on the brushes will not be zero (i. e., d.c.) any more, but that it will have a value of $f_2 = f_1 \times s$, proportional to the primary frequency and the "slip." We may conceive this performance as if there were generated in the rotating armature a frequency f_0 proportional to the actual speed of rotation (n), and this frequency is subtracted from the impressed frequency f_1, proportional to the **synchronous** speed n the resultant frequency (f_2) on the commutator brushes is always the difference between the two frequencies; impressed (f_1) and generated (f_0). For instance, at synchronism, the speed of rotation $n_1 = n$, hence the generated frequency $f_0 = f_1$, and therefore $f_2 = 0$; this checks all right with what we know so well of every conventional rotary converter. If—to take another extreme case—we will stall the armature, our reasoning would show that the "generated" frequency $f_0 = 0$, and that therefore the frequency on the commutator brushes will be same as is impressed on the collector rings, $f_2 = f_1$; this is of course true, because the commutator bars and the armature conductors of a stalled armature simply act as connecting wires.

If we increase the speed of rotation above synchronism, the "generated" frequency (f_0) becomes larger than the impressed frequency f_1. The commutator brush frequency still remains equal to their difference, $f_2 = f_1 - f_0$, only the phase rotation on the commutator goes in a direction opposite to the previous one.

Suppose we will drive the rotary armature in the opposite direction. The result will be that the "generated" frequency (f_0) will be **added** to and not subtracted from the impressed frequency (f_1); the commutator brush frequency $f_2 = f_1 + f_0$. The same result will be obtained if instead of reversing the direction of mechanical rotation, we will reverse two leads coming to the collector rings; this will have the effect of reversal of phase rotation of the impressed frequency.

In all cases, the voltage on the commutator has a definite and fixed relation to the voltage impressed to the rings; if the latter remains constant, the former will also remain **constant—regardless of any variation of speed and frequency.**

Thus the armature of a rotary convertor, applied as described, may be used for changing the available frequency. The commutator acts as a **universal frequency changer**; it may be made to boost or to buck the supply frequency, just like a well-known d.c. booster may be employed for boosting or bucking the line voltage.

The above three "elementary cases" will help us in analyzing the performance of the several systems of a.c. drives.

Scherbius System.

In the first shown layout (Fig. 8) the mill is driven by a slip ring induction motor M; direct connected to it there is an auxiliary or regulating machine R; it converts the slip energy of the motor M into mechanical power on the shaft; thus it is obvious that this is a constant horsepower drive.

The machine R has a three-phase stator winding, which acts as a field winding, and a d.c. armature with a commutator; but instead of two brushholder studs per pair of poles there are three studs, spaced 120 electrical degrees.

The field winding is connected through a transformer (Tr.) to the slip rings of the main motor M. Now, let us recall the conclusion drawn from the ele-

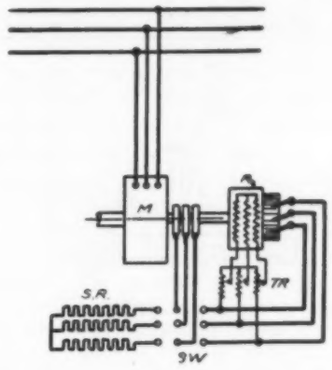

FIG. 8—*Diagram of principal connections of a single-range Scherbius drive with the regulating motor connected to the main motor; this layout is advantageous for constant horsepower drives. (M—main induction motor; R—regulating machine; Tr—field control transformer used for speed adjustment; SW—throw-over switch; SR—starting resistor).*

mentary "case 2": **The frequency at the commutator brushes is always the same as it is in the field;** thus the brush frequency is in this case the same as on the slip rings of the induction motor, regardless of he speed of rotation; it is therefore possible to connect the brushes of the machine R to the slip rings of motor M by closing the switch sw.; the emf. generated in the machine R "bucks" the secondary voltage of motor M and the latter slows down. By changing taps of the field control transformer tr. the value of the generated emf. and therefore the operating speed may be adjusted. Once adjusted, it stays practically constant, regardless of lead. It is possible to so arrange the exciting circuit of the machine R as to have control of the phase angle of the emf generated in it; if this emf. is made leading in respect to the secondary voltage, the power factor of the main motor may be corrected and brought to such high values as 95 per cent, or even unity, at all loads from mill friction load to full load, and at all operating speeds. The regulating machine R performs as a shunt wound d.c. motor and succeeds in converting with a single transformation the slip energy at widely different voltage and frequency into mechanical power on its shaft. The regulating machine is equipped with an interpole field winding; it is due to this and to few other design features that the commutation on this a.c. commutator machine is equal that of the best d.c. motors; this point contributed to the success of the Scherbius drives not less than the general simplicity of the principle involved.

Another layout for a Scherbius drive is shown on Fig. 9. The main induction motor is connected to the mill; the slip energy is brought to a separate high speed motor-generator (speed-regulating) set, consisting of a regulating machine R (converting the slip energy into mechanical power on its shaft) and of a squirrel cage induction motor K, which "pumps" this power back on the line. Obviously such drive is in-

herently of the constant torque type. The performance of the regulating machine is exactly the same as in the previous case; the regulating set runs at practically constant speed; the speed of the main motor M is adjusted by switching taps on the field control transformer Tr.

By comparing the two layouts, Figs. 8 and 9, we should note that the latter, although it involves the use of an extra machine (K), may present certain

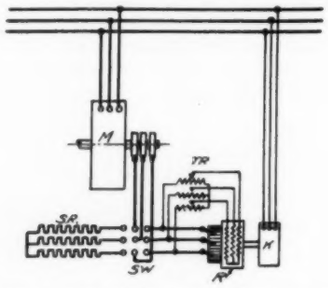

FIG. 9—*Diagram of principal connections of a single-range Scherbius drive with the speed regulating set located separately from the main motor; this layout is most advantageous for constant torque drives. (M—main induction motor; R—regulating machine; K—squirrel cage induction motor; Tr—field control transformer used for speed adjustment; SW—throw-over switch; SR—starting resistor).*

advantages. The speed of the regulating machine may be selected as is best suited for its design, without reference to the speed of the mill drive; the same size of regulating sets may be often used with different main motors. The latter may be geared or direct connected to the mill, whichever is deemed best suited for the installation; with the layout, Fig. 8, a direct connection of the drive to the mill is almost never possible, as a low speed regulating machine R will have a prohibitive cost. With a separate regulating set, which may be located anywhere, valuable space at the mill is frequently saved. The extra or third machine (K) is an ordinary high-speed squirrel cage motor; it is the least expensive and the most reliable electric motor; therefore it pays oftentimes to add it to the equipment and gain the several advantages of a separate regulating set, listed above.

However, the possibilities of the first layout, with a regulating machine direct connected to the main motor, should not be overlooked; high-speed geared drives are more frequently used at present than was the case 10 years ago; with a suitable motor speed and **constant hp. requirements** this layout may be more economical.

How much speed regulation is it possible to obtain with a Scherbius System? There are two factors that limit the regulating range: **Cost** and **commutation.**

The regulating set, as we know, handles the slip energy of the main motor. The greater is the desired speed range the larger becomes the maximum value of the slip energy, the larger and more expensive becomes the regulating machine. Thus a 1,000-hp. main motor, with 25 per cent speed regulation will require (neglecting losses) a 250-hp. regulating set. Obviously a commutator machine should cost more per horsepower than the main induction motor, and therefore in this example we will increase the cost considerably more than 25 per cent.

Secondly, the frequency handled on the commutator of the regulating machine is the slip frequency; it is proportional to the slip. At more than, say, 18 cycles, the successful commutation cannot be assured under mill conditions. This limits the regulating range of 60-cycle equipments to about 30 per cent from synchronism. With 25-cycle supply the cost and not the commutation is the limiting factor, but it is hardly economical to regulate more than 50 per cent from synchronism.

Double Range Operation.

In all our reasoning we have always assumed that the speed of the main motor is regulated down, below synchronism. Can it be regulated as well above synchronism? Let us refer to layout Fig. 9 and suppose that such operation is obtained. The emf. of the regulating machine should no longer "buck" the slip ring voltage of the main motor—it should "boost" it; the regulating machine does not convert the slip energy into mechanical motor power on its shaft—it takes the power from the motor K, transforms it into electrical power at slip ring voltage and frequency and feeds it to the rotor of the mill motor; the latter truly becomes "double fed": the stator furnishes its normal amount of power, corresponding to the rated output at synchronism, while the rotor receives an additional amount, proportional to the increase of speed; thus, with this layout, the shaft hp. output is greater, the higher is the speed; this is still a constant torque drive.

If we could at will operate below as well as above synchronism of the main motor, we would make a great stride in the right direction. With a regulating machine designed for only, say, 25 per cent regulation, we could go down to 75 per cent and up to 125 per cent, i. e., we would obtain with such **double range regulation** a speed ratio of 1.66:1 at about the same cost as we could obtain a ratio 1.33:1 with a single range equipment. This is in itself a very attractive proposition, and therefore, **all other things being equal,** a double-range drive should be preferred to a single-range equipment. It is evidently most advantageous to select the synchronous speed of the drive half-way between the maximum and the minimum speeds.

The equipment as considered thus far will run, as we have seen, below as well as above synchronism. Will it go **through** synchronism whenever we wish to boost the speed?

With the layouts shown on Figs. 8 and 9 this will be impossible. When the main motor runs at synchronism, the slip ring frequency **and voltage** are zero. There is no excitation in the regulating machine R, and no emf. can be then generated therefore, there is nothing to force a current through the secondary winding of the motor M, nothing to create a torque—and this is the only thing that may force the motor to go above synchronism.

To overcome this difficulty, a small exciter is mounted on the main shaft, Fig. 10. This is merely an armature like that of a rotary converter, with an iron ring pressed on it to complete the magnetic circuit, and rotating with the armature; the machine has no stationary part. The armature is wound for the same number of poles as the main motor. Slip rings are connected to the line through a transformer Tr-2. Now, this part of the layout is exactly like the elementary "Case 3," considered previously; we know that the armature will act as an "universal frequency changer," converting the line frequency to the frequency at the commutator brushes which depends on

the speed of rotation; we have noted that the latter frequency is always $f_2 = f_1 \times s$, where S is the "slip" below (or above) synchronism. This is exactly the same frequency that exists at the same time on the main motor slip rings, and therefore also in the exciting circuit of the regulating machine. The speed of the drive may change, but it is obvious that the

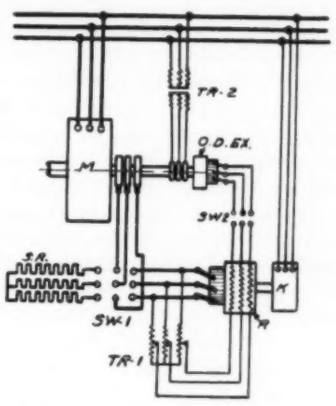

FIG. 10—*Layout of a double-range Scherbius drive. The addition of the "Ohmic Drop Exciter" permits speed regulation not only below but also at and above synchronous speed of the main motor, doubling the usefulness of the equipment. (M—main motor; R—regulating machine; K—squirrel cage induction motor; ODEx—Ohmic Drop Exciter; Tr-1—field control transformer used for speed adjustment; Tr-2—step-down transformer for O.D. Exciter; SW-1—throw-over switch; SR—starting resistor).*

equality of these two frequencies will be always automatically maintained. It is therefore perfectly feasible to close the switch Sw-2 and to give thereby an additional source of excitation to the machine R.

We have seen that the voltage of the frequency converter does not depend on the speed of rotation, but depends merely on the supply voltage; thus, when the drive goes through synchronism, the excitation for

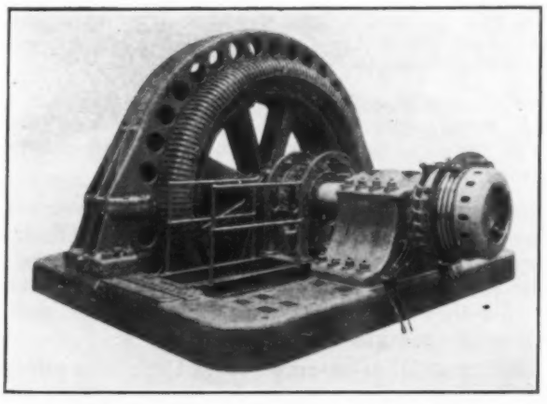

FIG. 11—*Main induction motor of the* 1850/1450/925-*hp.*, 120/94/60 *rpm. double-range Scherbius drive. Note the Ohmic Drop Exciter mounted on the shaft extension of the main motor.*

the regulating machine is still on hand. To be sure, the frequency at that time is zero, i. e., d.c. flows through the windings of the machine R and therefore through the rotor of main motor, but an emf. still may be generated in the regulating machine, and therefore the drive has full torque to go through and above synchronism.

When the excitation is at zero frequency, there is obviously no reactance in the circuit, and the exciter exc. should only cover the IR or ohmic drop in the windings; hence its name "ohmic drop exciter."

Although the double range operation was explained for the case of a separate speed regulating set, it can be just as readily adopted for the layout shown on Fig. 8. Double range equipments are especially valuable from the operating standpoint. The main motor, without regulating set, but running simply as a constant speed induction motor, may roll a greater part of the sections at the average mill speed. This increases the electrical efficiency of the drive; it may keep the mill going should any trouble be experienced with the regulating set.

The adjusting of speed is done as was explained by tap-changing on the exciter or field control transformer Tr., Figs. 8, 9 and 10. The taps are changed by means of a small contactor panel, remote controlled from a master switch. When passing through synchronism field contactors reverse the field of the regulating machine. By providing 8 taps, it is possible to obtain 17 operating points; 8 above, 1-at, and 8 below, synchronism; by adding only 2 more taps

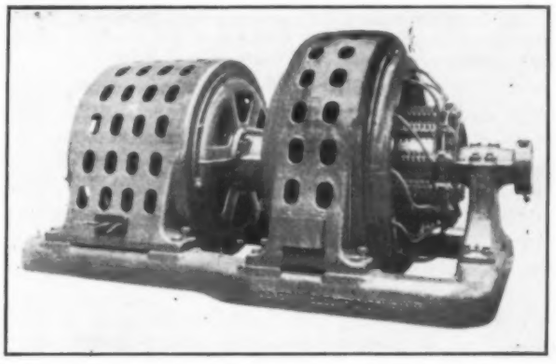

FIG. 12—*Speed regulator set for use with the* 1,850-*hp. main motor shown on Fig.* 11, *and mounted separately from it.*

it is possible to increase the number of speed points to 49, which is ample to meet the requirements of any mill.

Kraemer Drives.

In the Kraemer System the slip energy of the main induction motor is transformed through a rotary converter into d.c. power and the latter is then either returned to the mill drive shaft **(constant horsepower drive, Fig. 13)** or is further converted into a.c. and is returned to the line. **(Constant torque drives, Fig. 14.)**

In other words, the basic difference between the Scherbius and the Kraemer Systems is that while the former employs an a.c. commutator machine to convert the slip energy into mechanical power on its shaft, the Kraemer System does this by means of two machines: rotary converter and d.c. motor.

Theoretically it should be more expensive to employ two machines to do the work that can be done by one; practically it is sometimes possible to build for the same or lower cost two machines utilizing parts of standard design than one machine consisting of parts manufactured in smaller quantities. Thus there is a legitimate field for either system.

The operation of the Kraemer System may be readily explained.

By referring to Fig. 13, for instance, we see that the slip energy is brought to the collector rings of the separately mounted rotary converter R; the latter is separately excited and is running under its own power at a speed corresponding to the slip frequency; thus, whatever its speed, it is always a synchronous one, and therefore the rotary R always converts the slip frequency to d.c. power at its commutator. The d.c.

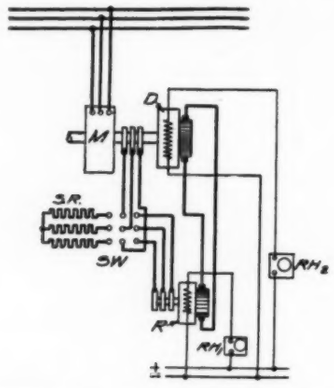

FIG. 13—*Elementary diagram of connections of a constant horsepower Kraemer drive. (M—main induction motor; R—rotary converter; D—d.c. motor; RH-1 and RH-2—field rheostats; SW—throw-over switch; SR—starting resistor).*

voltage is proportional to the slip voltage, i. e., it is also proportional to the slip frequency and to the speed of the rotary. The d.c. power is brought to the d.c. motor (D) and is returned to the shaft. When a layout as Fig. 14 is used, the d.c. motor is a high-speed machine connected to an induction (or synchronous motor K; the latter "pumps" the power back on the line.

By strengthening the field of the d.c. motor, its counter-emf. is increased, and this emf. acting through the rotary, "bucks" more and more the secondary volt-

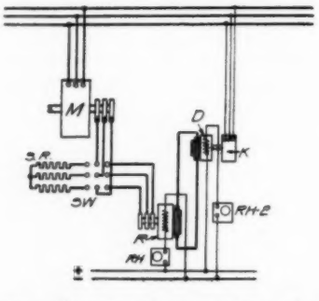

FIG. 14—*Elementary diagram of connections of a constant torque Kraemer drive. (M—main induction motor; R—rotary converter; D—d.c. motor; K—induction motor; RH-1 and RH-2—field rheostats; SW—throw-over switch; SR—starting resistor).*

age of the main motor; the latter slows down; in this manner the speed of the mill drive may be adjusted. By varying the field of the rotary R, the phase angle of the counter-emf may be advanced, and thus the power factor of the main motor may be corrected and brought close to unity. As we approach synchronism by weakening the field of motor D, the operating frequency of the rotary R approaches zero. This may cause the latter to fall out of step, especially when the mill load is heavily fluctuating. The use of flywheels becomes then desirable from the standpoint of stability. When the mill is loaded, it is seldom possible to run the rotary at less than 2 cycles; this makes a "dead zone" of about 8 per cent for 25-cycle equipments; if the total speed regulation is, say, 30 per cent, one-quarter of it is lost. With 60-cycle equipments the "dead zone" is only 3 per cent, and the problem of stability loses its importance. However, this feature readily explains that, quite unfortunately, the Kraemer drives cannot be brought under load conditions to and through synchronism; this prevents building them for double-range operation. **This is the most serious drawback of this system.**

As was explained in connection with the Scherbius drives, the capacity and cost of the machines used for speed regulation are approximately proportional to the per cent regulation. The single range equipments in order to give the same ratio of maximum to minimum speed, should be built for larger regulation and the regulating machines should, therefore, handle more power. Another drawback of **any** single-range drive is that the operation non-regulating (with the main motor running as constant speed machine) corresponds to the maximum operating speed, suitable for rolling small sections only.

The Kraemer System is at its best for 60-cycle equipments, as in this case a more or less standard 25-cycle rotary converter may be used, with modified fields. When the supply is 25-cycle, the rotary oper-

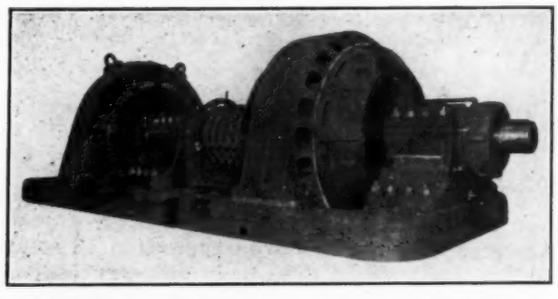

FIG. 15—*4,500-hp., 500/300 rpm. Kraemer drive, built by the General Electric Co. This is the largest Kraemer equipment ever built and will be used for driving the 14-in. merchant mill of the Inland Steel Company. The elementary layout of the mill is shown on Fig. 24.*

ates at a very low frequency (not over 12.5 cycles for even 50 per cent maximum regulation) and this makes this machine slower and more expensive.

In a good many cases the rotary converters are built for six phases, in order to improve their efficiency; this requires bringing out six ends of the main motor secondary winding, and furnishing of six slip rings for this machine as well as for the rotary.

Frequency Changer System.

This is another attempt to put the slip energy to work. The system, as it has been applied in this country (See Fig. 16) consists of the main motor (M), frequency converter F, driven by a small synchronous motor (P) and of the synchronous motor (S), returning the power to the drive shaft. In this form this is a constant horsepower equipment.

The synchronous motor P runs from the a.c. supply; it is a small machine of a capacity only sufficient to cover the losses in the frequency converter F; the latter converts the electric power of one frequency and voltage directly to electric power of another frequency and voltage, and there is no power developed on the shaft of the machine F, except the torque de-

veloped by motor P to cover the losses. The machine F has no excitation and its magnet frame is simply a laminated core, required to carry the rotating flux.

The commutator brushes of the converter (F) are connected to the slip rings of the main motor; the converter is driven at a strictly synchronous speed; its collector rings are connected to the stator of the synchronous motor S, which is excited by d.c. and therefore generates a.c. of frequency depending on the speed of rotation. The synchronous motor has the same number of poles and is direct connected to the main motor M.

The elementary "Case 3," which we have considered previously in this paper, will assist us in understanding the relation and interaction of the several frequencies involved in this scheme. Let f_1 be the line frequency; for instance, $f_1 = 60$ cycle; say the main motor runs with a slip $s = 25$ per cent, and therefore, the secondary frequency is $f_2 = s \times f_1 = .25 \times 60 = 15$ cycles. The synchronous motor S runs at 75 per cent speed and therefore it generates a frequency of $f_3 = .75 \times f_1 = 45$ cycles. Now, the frequency changer F runs at synchronous speed, therefore the frequency "generated" in it $f_4 = 60$ cycle; we know, from the "Case 3" that the resultant frequency at the commutator brushes is the difference (or sum) of frequency impressed on the collector rings ($f_3 = 45$ cycle) and that generated in rotating armature ($f_4 = 60$ cycle); therefore the resultant frequency

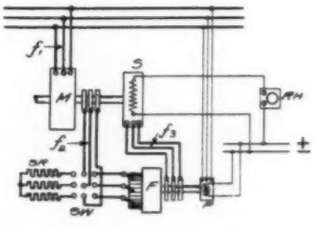

FIG. 16—*Elementary diagram of connections of a constant horsepower frequency converter drive. (M—main induction motor; F—frequency changer; S—synchronous motor; P—small synchronous motor for driving the frequency changer at strictly synchronous speed; RH—field rheostat; SW—throw-over switch; SR—starting resistor).*

is $f_4 - f_3 = 60 - 45 = 15$ cycles, i. e., the same value that is at the same time on the slip rings of the main motor M. This permits the connection of M to the commutator of F.

By increasing the excitation of the synchronous motor S, the speed of the drive is reduced; the weakening of the field causes the raising of speed; at synchronism no field is required, while the reversal of it will cause the drive to go through synchronism. In other words this system may be built for double-range operation.

Although no drives like the one shown on Fig. 17 were built nor installed in this country, it is worth while to note this layout as it indicates another way of making use of a frequency converter.

The latter runs in this case at the same relative speed as the main motor; it may be mounted directly on the motor shaft, or may be built for a higher speed and "electrically geared" to the shaft; two small synchronous machines (one—SG, working as generator, the other, SM,—as a motor) constitute this "electrical gear."

The slip energy is brought to the commutator of the convertor F; it is transformed into electrical power of the primary frequency and is returned to the line. Thus this is a constant torque drive.

The relation of the frequencies in the various circuits may be made clear by the following reasoning, assuming the same designations as in the preceding case.

Let:

(a) The line frequency..... $f_1 = 60$ cycle
(b) The main motor slip, say..... $s = 25\%$

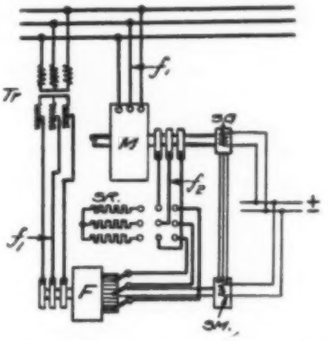

FIG. 17—*Elementary diagram of connections of a constant torque frequency converter drive. (M—main induction motor; F—frequency changer; SG and SM—small synchronous generator and motor; Tr—transformer for transmitting the slip energy between the line and the frequency changer, and used for speed adjustment; SW—throw-over switch; SR—starting resistor).*

(c) The slip frequency is.... $f_2 = f_1 \times s = 15$ cycle
(d) The mechanical speed of the main motor, and therefore of the machine F, is proportional to..... .....$f_1 (1—s) = 60 \times .75 = 45$ cycle
(e) The frequency "generated" in the converter F is proportional to its speed... ..... $f_3 = f_1 (1—s) = 45$ cycle
(f) The frequency applied to the collector rings of F- is the line frequency.. $f_1 = 60$ cycle
(g) The resultant frequency at the commutator brushes is the difference between the applied and the generated values... ..... $f_1 — f_3 = 60 — 45 — 15$ cycle

Thus the frequency at these brushes is always the same as at the slip rings of the main motor M; it is therefore possible to connect electrically the two circuits.

By changing taps on the transformer (Tr) the voltage impressed on the slip rings of motor M may be varied, and the speed of the drive adjusted.

Power Factor Correction.

It has been noted in the foregoing that the several systems developed for regulating the speed of induction motors, by converting the slip energy into useful mechanical or electrical power, all provide means of incidentally correcting the power factor of the main induction motor.

While the means of obtaining this result are not alike, the fundamental principle is the same:

The secondary current of an ordinary induction motor has practically no wattless component; it is proportional to the load which the motor is carrying. The primary current has a watt-component, to correspond to the above secondary current, and in addi-

tion to it, a wattless component or the magnetizing current required to create the magnetic flux. It is for this reason that the resultant power factor of the motor is less than unity, especially on light loads, when the proportion of the magnetizing current is greater.

To off-set this feature of the induction motor, all power-factor-correction schemes endeavor to advance the phase of the secondary current, i. e., to make it **leading,** by injecting in this circuit a leading emf. The leading wattless component of the secondary current, transposed on the primary (if of proper value) compensates for the magnetizing current, and brings the line power factor back to unity.

Thus, we do not get "something for nothing;" we actually "spoil" the power factor in the rotor circuit in order to improve it in the incoming line, where it is most needed; the secondary current, however, becomes larger, and the copper losses increase. The regulating machines used for speed adjustment of the main motor, carry the full secondary current; hence the kva. capacity of these machines increases in a certain proportion to the desired degree of power factor correction; this **may** increase the size of the regulating machines. They are expensive machines, in dollars per kva.; therefore it is not always economically sound to insist on a greater degree of p.f. correction than the speed regulating equipment is inherently good for. A power factor of 90 per cent or 95 per cent (lagging) should be considered as quite satisfactory; it may be made available at all speeds, and at all loads within the operating range; an addition of such drive will usually improve the average power factor of the plant. No attempts to obtain a leading p.f. of an a.c. mill drive should be encouraged; for such purpose the use synchronous condensers will be found more economical than building-in excessive correction kva. in say, the Scherbius machine or in the inherently "unity-p.f." machine like the rotary converter of the Kraemer system.

Brush Shifting Motors.

Since 1890 when Elihu Thompson built the first repulsion motor, the principle of speed adjustment of an a.c. commutator motor by brush-shifting was known. This principle is attractive, indeed, for it gives a promise of obtaining with a single motor and with a simplest control, what is being accomplished by several machines in any of the reviewed schemes.

However, many attempts to build an a.c. commutator motor of such size as is needed by large rolling mills—attempts made both in this country and abroad —did not materialize on account of engineering and economic reasons.

An a.c. commutator generally includes the most expensive part of an induction motor—stator—and the most expensive part of a d.c. motor—armature this fact alone makes it cost higher than that of either machine. Furthermore, the necessity of handling the entire power of the mill drive on the commutator and of handling it at the full line frequency introduces appreciable engineering difficulties. As against this, such drives as Scherbius or Kraemer, as we know, handle on their commutator machines only the slip energy—comparatively small part of the whole—and the commutation proceeds at a low, slip frequency.

But when it comes down to drives of small size, the cost of the speed-regulating equipment and control becomes relatively high, and if the use of a.c. to d.c. conversion is not economically justified, there opens a field for a self-contained adjustable speed a.c. motor.

The General Electric Company has built during the last few years a large number of brush-shifting polyphase motors, with speed ratios as high as 3:1. These motors have substantially a "shunt speed characteristic" and are therefore applicable to drives where the load varies all over the range. While most of these machines were built in sizes ranging from 5 to 75-hp., two motors of this type, rated at 500-hp. and 600-hp., were built for rolling mill duty. This undoubtedly justifies that we give in this place a brief outline of such motor, leaving a more complete description for another time.

Assume that we take a properly designed phase wound induction motor and connect its slip rings to the power supply; the stator winding, which will act in this case as the secondary winding, may be connected to a starting resistor and will be normally short-circuited, thereby permitting the motor to carry load with a reasonably small slip. Thus far the performance is that of an ordinary induction motor. If we want to adjust its speed, we must apply to the secondary winding—on a well-known general principle—an emf. of the slip frequency. To this end special provisions are made, as follows:

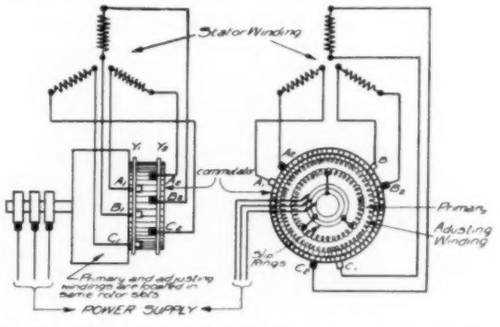

FIG. 18—*Two diagrams of connections of a brush-shifting polyphase motor, General Electric type Bta.*

In the slots of the rotor there is imbedded an additional so-called "adjusting" winding, which is nothing else but a d.c. armature winding connected to a commutator. (See Fig. 18). The primary and the adjusting windings, although they are laid in the same slots are not connected electrically to each other; there exists, however, a magnetic interlinkage between the two windings, and as they are stationary with respect to each other, the frequency in both is always the same, and equals the line frequency. They act on each other exactly like two transformer windings; the fact that both are rotating together does not alter, of course, their interaction. In the same way the voltage induced in the adjusting winding is of constant value, independent of the speed of rotation.

The frequency at the brushes of the commutator, to which the adjusting winding is connected, is, however not the same as in the adjusting winding itself. The case is just like the "elementary case 3," considered previously with this difference, that the line frequency is not directly impressed to the winding connected to the commutator, but is induced in it through a transformer action. We know that under circumstances the frequency on the commutator brushes is

the "slip frequency," i. e., if a 60-cycle motor runs with a 15 per cent slip, the frequency on the brushes will be $0.15 \times 60 = 9$ cycles. This is exactly the same frequency that exists at the same time in the secondary (stator) winding.

Let us now put on this commutator two brushholder yokes Y_1 and Y_2, Fig. 18. Each yoke is equipped with an independent set of brushes, spaced for polyphase operation, i. e., in case of a three-phase combination the brushes are spaced 120 electrical degrees apart. The ends of each phase of the stator are brought out and are connected: one end to a brush on the brushholder yoke Y_1, the other end to a brush on the yoke Y_2; the respective brushes are marked on the Fig. 18 by letters A_1, B_1, C_1 and A_2, B_2, C_2. Now, when the brushes A_1 and A_2, B_1 and B_2, C_1 and C_2 respectively are set opposite each other (Fig. 19-C),

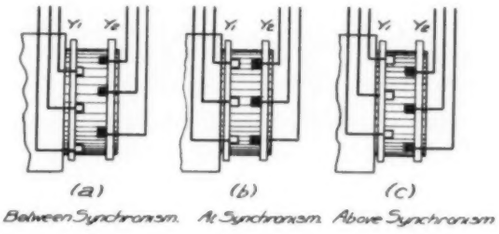

FIG. 19—*Relative position of the two brushholder yokes of type Bta. motor at different operating speeds.*

i. e., on the same commutator bars, each phase of the secondary winding is simply short-circuited through these bars therefore the motor runs at the same speed as if it were an ordinary induction motor.

Suppose we move the brushholder yoke Y_2, say clockwise, and Y_1, counter-clockwise (See Fig. 19-A); the brushes A_1, A_2, B_1, B_2 and C_1, C_2 will then be located on different commutator bars, and there will exist a difference of potential or voltage on each pair of brushes. This voltage, which always is—as was noted—of the slip frequency, will be the greater, the larger is the angle of the brush shift. This voltage is impressed on the secondary winding; suppose that with the brush shift as shown on Fig. 19-A, the injected voltage "bucks" the secondary voltage of the motor; this will cause the motor to slow down. When the brushes are shifted in the opposite sense, yoke Y_2 — counter-clockwise and Y_1 — clockwise (See Fig. 19-C), then the "brush" voltage boosts the secondary voltage, and the motor speeds up above synchronism. If the adjusting winding is designed to give 50 per cent speed regulation, we may increase the motor speed up to 150 per cent synchronous or reduce it to 50 per cent, i. e., provide a speed range of 3:1.

The energy handled in the adjusting winding and on the commutator is only the slip energy, and in this respect this motor (known as the type "Bta.") differs radically from many other a.c. commutator machines, where the commutator handles the entire power. Really, a Bta. motor may be compared to, say, a Scherbius equipment built in one machine. The secondary current of this motor is substantially the same at all speeds and is proportional to the torque. This current limits the output of the machine and makes it inherently a **constant torque motor.**

The speed control consists of a few gears and pinions, comprising the brush-shifting mechanism; **both yokes are turned simultaneously in the opposite** directions by turning one handle. If remote control is desired a small pilot motor is applied.

The Bta. motor is started by simply throwing it on the line, preferably with the brushes set at the low-speed position; in such case the starting current will be about 150 to 170 per cent normal; the starting torque is well above 200 per cent normal. If the value of the starting current should be reduced still further, or when it is desired to "plug" the motor while it is running, an external resistor may be provided, which is inserted between the brushes and the stator winding. This resistor, if furnished, is normally short-circuited by a contactor, **and comprises the only control equipment of such drive.** This freedom from control apparatus makes the equipment extremely simple.

In smaller capacities, up to 75-hp., the Bta. motors are already a proven success. Two large motors were built for the Halcomb Steel Company, Syracuse, N. Y., and are rated:

One 14-pole, 600/200-hp., 307/102-rpm., 440-volt, 25-cycle motor for driving a 9-in. merchant mill.

One 30-pole, 500/250-hp., 130/65 rpm., 440-volt, 25-cycle motor for driving a 14-in. merchant mill.

At this time* the first motor has successfully passed complete factory tests and is being installed at the mill. The second motor is still under construction. On the general principle that nothing should be claimed until proven by actual practice, it is premature to say how these two pioneer motors will drive

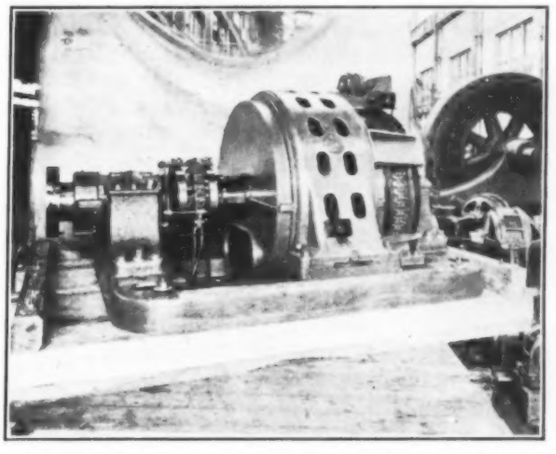

FIG. 20—*Shop view of a type Bta. 600/200-hp., 307/102 rpm., 440-v., 25-cycle motor built for driving the 9-in. mill of the Halcomb Steel Company. The speed is adjusted by operating the brush-shifting mechanism by means of a ¼-hp. pilot motor, seen on the photograph. This Bta. motor is designed for forced ventilation.*

their mills; but successful factory tests leave very little doubt that the results will fully meet the expectations.

A reliable and self-contained adjustable-speed a.c. motor will undoubtedly meet the long-felt want for that kind of drive, especially for mills of small and moderate size.

D.C. Drives.

Under certain conditions, fully explained in the latter part of this paper, the best results are obtained when d.c. motors are used for making up adjustable-speed mill drives. The available power being always

*August 11, 1924.

a.c., this system requires the use of converting apparatus; either motor-generators, usually driven by synchronous motors, or rotary converters with step-down transformers.

When the d.c. bus voltage is maintained constant, the motors are started by resistance control, and the mill speed is adjusted by motor field control; this is the only method available when rotary converters are employed in preference to m-g sets. In the latter case the mill motor control may remain the same, or else each motor may have a corresponding separate generator and by varying its voltage the motor speed may be adjusted; no separate starting control is then needed. Sometimes the combination of motor field control and of the voltage control is used.

Field Control.

When the motor field is weakened, with line voltage remaining constant, the motor speed increases. Will the capacity of a d.c. motor be different at the various speeds, which may be obtained in this manner?

The capacity of a d.c. machine is limited by two factors: heating and commutation. The heating, proportional to the load, depends primarily on the armature current. Assuming the same efficiency at all speeds (this is approximately true) the same armature current will produce, the voltage remaining constant, approximately the same horsepower output at the motor shaft at all speeds. **Thus, a d.c. motor with field control of the speed is inherently a constant horsepower drive.** By making this statement we neglect the influence of the improved ventilation at the high speed, and disregard the possible influence of the commutation in limiting the output and the overload capacity with a very much weakened field.

If the mill requires a constant torque drive, the d.c. motor should be proportioned to give the required torque even with the weakened field. At the minimum speed this motor will have more torque than is required, and such drive is therefore more expensive

The commutation is always better at the low speed, when the motor runs with full field, and the effect of flux distortion produced by the armature reaction is then less noticeable. When the speed range is considerable, say, 2:1 or more, it usually becomes necessary to provide a compensating or pole-face winding to reduce the effect of the armature reaction on the so much weakened field. A speed range of 3:1 is seldom exceeded in d.c. mill drives with purely motor-field control.

Voltage Control (Ward-Leonard Control).

This arrangement requires a separate generator for each motor, unless it is feasible to adjust simultaneously the speed of several mills in the same proportion. The generator voltage may be varied from zero to its maximum strength and this will start the mill motor and bring it to the desired speed.

The speed of the mill motor varies as the voltage applied to it; the current-carrying capacity is the same at all speeds (neglecting the difference in ventilating conditions); the motor field remains at its maximum strength. As the motor torque is proportional to the product of armature current and of the field strength, this system is inherently a **constant torque** proposition.

Because the mill motor runs with full field, the commutation is equally good throughout the range. Capacity to take momentary peak loads remains the same. Compensating field-windings are not required.

The generator, however, is supposed to carry the same current at all mill motor speeds, i. e., even with the generator field much weakened. These are not the best conditions for the commutation, and it becomes necessary to provide the generator with a pole-face winding. Once this is done, the generator should be capable of running the mill motor at any speed, from zero to its maximum.

When the mill requires a constant horsepower drive, but Ward-Leonard speed control is attempted, the mill motor and the generator should be designed for a larger current at low speed and voltage, than at high speed and voltage. The proper thing would be to use the Ward-Leonard control for starting the starting the motor from rest to bring it to its full field or base speed (this will be the minimum operating speed) and to further increase that mill speed by motor field control. This operation is closely related to the next system presently described.

Combination of Voltage (Ward-Leonard) and Motor Field Control.

Sometimes the study of mill requirements shows that the lower part of the speed range requires a constant torque, while for the upper part a constant horsepower is satisfactory. For instance, the points on Fig. 21—A indicates the horsepower requirements of the mill; the speed range is 200/500-rpm. It is most advantageous to control the speed from 200 to about 350-rpm. by generator voltage; the motor torque remains constant (say 30,000 lb. ft.) and the horsepower varies from 1,150-hp. to 2,000 hp. From 350 to 500-rpm. the speed will be adjusted by motor field; the available horsepower will remain constant, but the torque will decrease inversely proportional to the speed. With this operation, the combined design of the mill motor and generator becomes most economical.

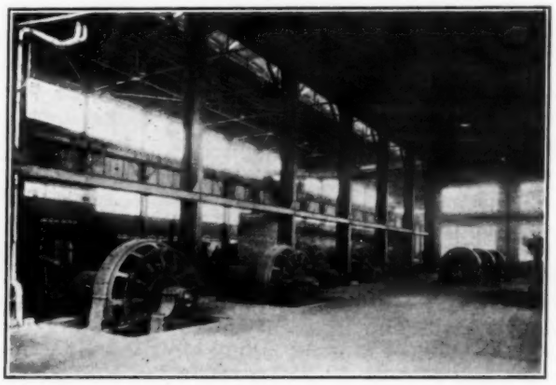

FIG. 21—*Motor room of the hot-strip mill of the Otis Steel Company. Three* 1,500-*hp. motors (only two are seen on the photograph) and three* 1,800-*hp. motors are used for driving the finishing stands of the mill; speed range of each motor is* 2:1.

The great majority of reversing mill drives employ the just described combination of generator and motor field control.

D. Comparison and Selection of Systems.

The multiplicity of systems of adjustable speed drives, each developed with an idea to give a best

drive for a given class of mills, may lead to a confusion in making a choice, and—worst of all—to a misapplication.

We can readily understand the puzzle of a mill operator who is once advised by electrical engineers to install an a.c. drive for one of his mills, and is told again in a little while that his other mill undoubtedly requires d.c. motors. As men interested in the use of

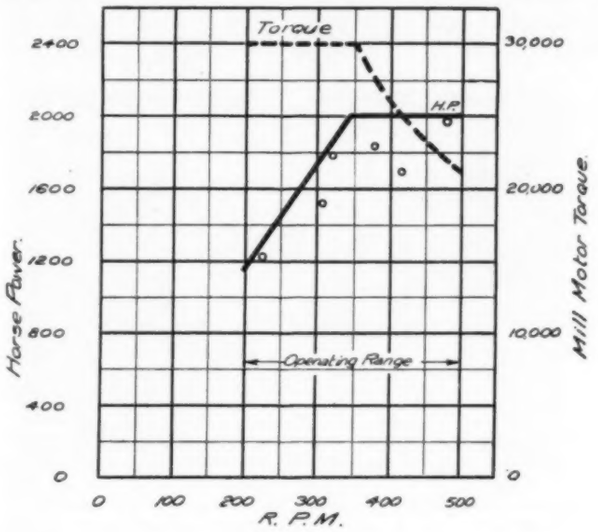

FIG. 21-A

proper electrical apparatus in each case, we must discuss this question among ourselves, must come as near to a conclusion as different, but sincerely held, points of view will permit, and should then be ready to justify on engineering ground every choice that we make.

Instead of arguing this question in a general abstract way, it seems best to analyze several examples and to show what, in our opinion, should be considered as a proper drive in each case.

Example 1. This is a very popular layout of a Belgian merchant mill (Fig. 22). It consists, say, of a 16-in. single-stand rougher and of a 10-in. 5-stand finisher. It receives reheated 4x4-in. or 5x5-in. billets and rolls them down to such merchant shapes as for instance ⅜-in. rounds, 1x¼-in. flats, ¾-in. squares,

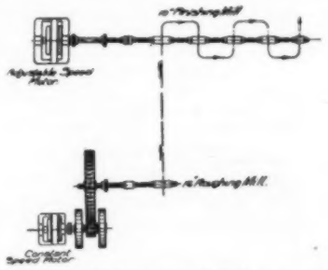

FIG. 22—*Layout of a widely used Belgian merchant mill. The roughing stand is shown as driven by a separate constant speed motor; an adjustable speed drive is usually required for the finishing train. This is a good application for an a.c. drive.*

etc. The power supply is 2,200-v. 25-cycle, and the mill is running independently of other mills.

It is unquestionably best to provide separate drives for the rougher and the finisher; each mill may be then operated separately, if so desired, and the speed adjustment of the 10-in. mill will not interfere with the roughing work.

The 16-in. roughing stand may run at a constant speed of about 90-rpm. a constant speed induction motor of, say, 400-hp., 500-rpm. is likely to be selected and will be geared to the mill. The finishing mill requires a speed adjusted between the limits of, say, 200/300-rpm. The drive capacity required is estimated to be 700-hp. at the average speed of 250-rpm. Should this be a d.c. or an a.c. drive?

Our choice should be unquestionably in favor of a.c. The available a.c. power will be used without further transformation to drive the mill; the main motor will be of the most reliable—induction motor—type; only the slip energy when running regulating will have to be re-transformed; but this amount with a double-range system, will be only 20 per cent of the total power at the maximum regulation, so that the overall efficiency is high (about 88 to 89 per cent). Furthermore, if the a.c. drive is of a double-range type, the majority of the sections may be rolled with the main motor running non-regulating, increasing the efficiency still further, to about 93 per cent.

On the other hand, a d.c. drive will require a separate motor-generator set or an additional capacity of other sets. This means that available power would be transformed three times in succession from electrical to mechanical and reverse before it reaches the mill spindle. This reduces the overall efficiency to

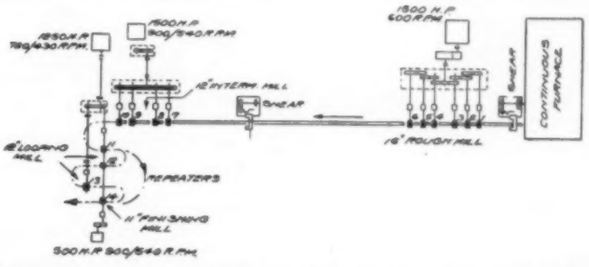

FIG. 23—*Layout of the* 16-*in. by* 12-*in. by* 11-*in. merchant mill of the Tenessee Coal, Iron & Railroad Company. The roughing train is driven by a constant speed induction motor; three other drives are of the a.c. adjustable speed type, with speed range of* 1.66:1.

about 81 to 82 per cent. Also note that in this case the whole power would be transmitted in succession through two commutators: on the d.c. generator and on the mill motor. As against this, with an a.c. drive for this mill, the power handled on the commutator of the regulating machine is never more than 20 per cent. Combined with the simplicity of the main induction motor, this makes the maintenance cost of the a.c. drive much less.

The question of constant horsepower vs. constant torque was purposely omitted in this place. Calculation should decide this point in each case, as was explained, and an a.c. drive should be selected accordingly. The choice between the Scherbius and Kraemer systems will be made on the basis of cost and of the comparative merits of double vs. single range operation.

Example 2. This is a large merchant mill, shown on Fig. 23. It consists of a 6-stand 16-in. continuous roughing train, 4-stand 12-in. continuous intermediate train, 3-stand 12-in. looping mill and a single 11-in. finishing stand. These four mills are driven by separate electric drives, to give the greatest flexibility in

adjusting the speed required to take care of such variety of products as 1¼ and ½-in. squares or concrete bars, 1½ and ⅜-in. rounds, 3x⅛-in. flats, etc.

The initial section is the same in all cases, namely 4x4-in. billets; thus it is not very essential to vary the speed of the 16-in. roughing train, and it is driven by a 1,500-hp. constant-speed induction motor. The speed range of the three other drives, shown on Fig. 23, is 1.66:1, the capacity being 1,500-hp., 1,250-hp. and 500-hp. for the three respective mills. The available power was, of course, a.c. of 6,600-v. 60-cycle.

The speed range of the three drives is moderate, and this is favorable to the a.c. system, because we know that the cost of speed-regulating equipment depends very largely on the amount of regulation. The efficiency of the a.c. drives was considerably higher than of any possible combination of motor-generator sets and d.c. motors. The layout of the mill is such that the permissible looping of the metal can very well take care of some inequality of relative speeds of the three drives; therefore the finer speed adjustment (i. e., smaller variation of speed from full load to no load) obtainable with d.c. drives was of no particular advantage in this case.

As a result, the choice was quite correctly made in favor of a.c. drive. Scherbius and Kraemer systems were considered; the fact that the power supply was 60-cycle assisted in lowering the cost of the Kraemer drives. This system was finally selected on the basis of cost.

Example 3. The mill, shown on Fig. 24, is the new 14-in. merchant mill of the Inland Steel Company. The layout calls for one single drive, with 1.66:1 speed

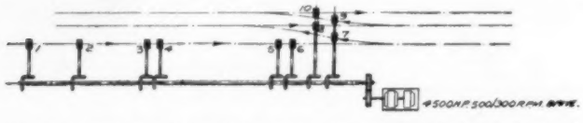

FIG. 24—*Layout of the 14-in. merchant mill of the Inland Steel Company. The mill is driven by a 4,500-hp. Kraemer equipment shown on the photograph Fig. 15. This is an ideal application for an a.c. drive; as compared with d.c. first cost is much lower, and the saving in power consumption is very appreciable.*

range. (Constant horsepower 4,500-hp. was required throughout this range). **This is an ideal application for an a.c. drive.** A Kraemer drive, shown on the photograph, Fig. 15, was chosen. Its efficiency was:

At maximum speed and full load—90 per cent.

At minimum speed and full load—89.5 per cent.

If a d.c. were selected, with a motor-generator set, the overall efficiency from the incoming line to the mill coupling would not be over, say, 83 per cent.

Thus the selection of a d.c. drive for this mill would reduce the efficiency by 6 to 7 per cent. Assuming average values for steel mills of this kind at about 60 kwh. per ton, and 1 cent per 1 kwh., the choice of a.c. drive saves approximately 4 cents per ton. This may be more than ample to pay for the entire maintenance of the equipment. A d.c. drive should and would increase the maintenance cost per ton, without giving in this case any advantages whatsoever.

Example 4. There is probably no more interesting comparison of the a.c. and d.c. systems than in the case of the hot-strip mills of the Trumbull Steel Company. Built for rolling identical products, equipped by the same electrical manufacturer, the 16-in. and the 14-in. mills are, however, radically different in their layout and operation.

The layout of the 16-in. hot-strip mill, as it existed until recently, is shown on Fig. 25. It is essentially a cross-country mill, with two broadside transfers. The stands are so spaced that there is practically no

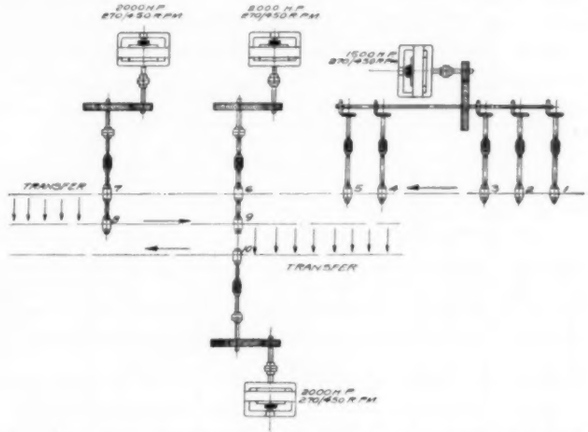

FIG. 25—*Layout of the 20-in. by 16-in. hot-strip mill of the Trumbull Steel Company. The mill is of the cross-country type and is driven by four double-range Scherbius drives. This layout does not require the use of the less efficient d.c. drives.*

looping between the stands; "synchronous" operation of the four drives, regardless of the load imposed on each, was not very essential. The mill has an exceptional flexibility and the change from order to order is made without any loss of time.

The speed range of each drive is 1.66:1. With the double-range Scherbius system used, the capacity of the regulating machines was only about 25 per cent of the main motor capacity. This made the cost of the a.c. drives more attractive than of d.c.; the efficiency was higher; the mill layout and the rolling conditions permit occasional running of one or two drives non-regulating, thereby reducing the losses and maintenance. There is no doubt that the choice, as made, was a correct one.

The 14-in. hot-strip mill, Fig. 26 and Fig. 27, is built on the straight continuous principle. The stands are located as close to each other as possible; the same bar may be in practically all stands at the same time.

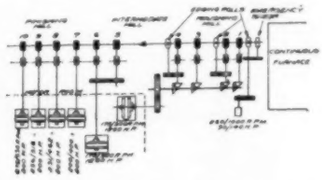

FIG. 26—*Layout of the 14-in. hot-strip mill of the Trumbull Steel Company. The mill is built on the continuous principle, with individual drives for the finishing stands. Very close speed regulation is essential and the selection of d.c. motors was fully justified.*

This, in itself, is not an innovation, as a good many Morgan mills work under similar conditions; in most of them, however, the individual stands are driven from a common lineshaft; this insures proper relative speeds between stands, once the rolls and drafts are adjusted, but any change of rolling order requires con-

siderable time for re-adjustment. Such mills are suitable for large orders, but are not flexible. It was therefore intended to combine two desirable features: large tonnage capacity of a continuous mill and flexibility of readjustment of speed.

The 10 stands of this mill are driven by six separate motors: the first four roughing stands by a 1,250-hp. motor, the next two stands by another 1,250-hp. machine, and the four finishing stands each by an 800-hp. motor. Each machine has a 2:1 speed

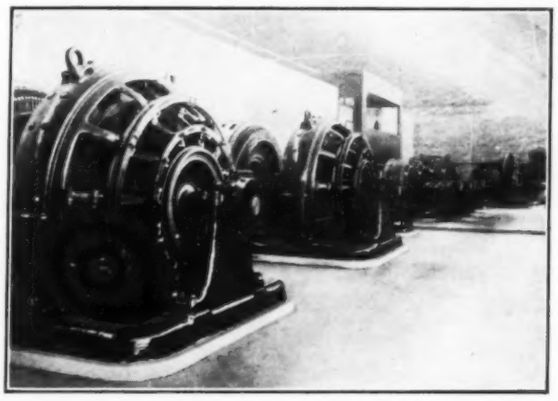

FIG. 27—*General view of the motor room of the* 14-*in. hot-strip mill of the Trumbull Steel Company; the mill layout is shown on Fig. 26. Two* 2,300-*kw. synchronous motor-generators are seen in the foreground, followed by four* 800-*hp. d.c. motors; the two* 1,250-*hp.* d.c. *motors driving the roughing stands are seen in the background.*

range and the speed of each is independently adjusted by motor field control. It may be truly said that we have substituted the conventional lineshaft of a continuous mill by an electric bus, and have introduced flexible reduction gear units between the lineshaft and the stands. The advantages of this are self-evident.

But this layout imposes some very severe requirements on the driving motors: once their speed is adjusted it should remain constant, within a fraction of 1 per cent; any unforeseen change of speed due to variation of load, etc., may cause excessive looping or stretching of metal. Remember that the distance between centers of the finishing stands is as small as 7-ft. 6-in., and the delivery speed is close to 2,000 ft. per min.

The a.c. adjustable-speed drives retain and amplify to certain extent the characteristic of an induction motor: slight drop of speed with the load. A closer study of this proposition had shown that for this sake alone the Trumbull 14-in. mill should be driven by d.c. shunt motors; special regulators were designed to hold the speed ratio constant, once it was set. The practice has shown that the inherent speed regulation of the d.c. motors built for this mill was so good that the use of the special automatic speed controlling devices was not essential.

A cost analysis would also prove that in this case the decision in favor of d.c. did not impose an excessive cost burden on the electrical equipment: on one hand for the six mill drives only two 2,300-kw. motor-generator sets were used, i. e., each motor has to share the cost of only one-third of a large set instead of requiring a separate set of one-third capacity. On the other hand the cost per horsepower of 800-hp. a.c. drives, with 2:1 speed range would be higher than that of 2,000-hp. drives with 1.66:1 range, as used for the 16-in. mill, Fig. 25. The overall efficiency of the d.c. drives is of course less, but this is a sacrifice that had to be made in order to obtain the desired speed control.

In the last few years the continuous mills with tandem drives, as described, have been gaining in popularity and several of them were installed. For the same reasons as in case of the Trumbull 14-in. mill, d.c. drives were applied for driving individually either all stands or the intermediate and the finishing ones. To some outsider it may appear as if the d.c. had the better of the argument with the a.c. adjustable-speed mill drives; as a matter of fact the latter have lost none of their attractive features; they will have an inherent advantage over their d.c. competitors as long as a.c. power is used for generation and distribution. **One should use a.c. drives whenever possible, and d.c. only when it is necessary.**

Conclusions. The few examples which were just analyzed have illustrated the general line of thought to be followed in selecting a proper adjustable speed drive for rolling mills. While it is extremely difficult to set hard and fast rules for making the choice, the following conclusions are believed to be generally true:

(a) An a.c. drive has a better efficiency than a d.c. drive. The larger is the mill tonnage, the more valuable becomes each per cent gained in efficiency.

(b) A.c. adjustable-speed drives are capable of correcting **their** power factor and of bringing it close to unity. D.c. drives with synchronous motor-generators have leading power factors on the a.c. line, and are capable of providing leading corrective kva.

(c) When isolated mill drives are considered, the a.c. drives will, in most cases, be found lower in the first cost and in the maintenance. Their reliability is greater.

(d) With several drives driving the same mill the d.c. proposition may have a lower first cost. Only a close analysis will show where is the dividing line .

(e) The increase of speed-regulating range is more expensive with a.c. drives than with d.c. A speed range of substantially more than 2:1 may be too expensive for a.c.

(f) The larger is the capacity of the drive, all other things being equal, the more prominent become the advantages of the a.c. drives. For very small capacities, like 300 to 400-hp., the cost per horsepower of the regulating equipment for an a.c. motor becomes high.

If the choice is to be made between the Scherbius and Kraemer systems, the following factors should be noted:

(g) The Scherbius system can give a double-range operation; the main motor can run non-regulating and roll the majority of sections at the average speed.

(h) The efficiency and power factors of either system are about the same.

(i) Either Scherbius or Kraemer can be built for constant horsepower or constant torque.

On the same basis the Scherbius system employs one machine less than Kraemer.

(j) The control of the Scherbius drives is somewhat more complicated, and it is claimed by some that it takes a longer time to break-in a new attendant. The control, however, consists of standard devices and is just as reliable as that of any constant speed induction motor.

(k) The use of 60-cycle power as compared with 25-cycle lowers the cost of the Kraemer drives, but does not increase the cost of the Sherbius equipments. The speed regulation of the 60-cycle double-range Scherbius drives is limited to approximately 30 per cent above and below synchronism, i. e., to a maximum speed range of 130:70 = 1.85:1.

Nowhere as in the question of adjustable speed drives should the engineering analysis be given a freer hand. Prejudices against one system, foregone conclusions in favor of another will not land us any nearer our ultimate goal. It is far better to spend a little more time with pencil in hand, making a complete preliminary study of the subject, than to make a rash and possibly wrong decision and then pay for it in tons of steel that **might have been rolled.**

The Steel Industry and the Electric Utilities

By MERRILL SKINNER* and F. D. MAHONEY†

IN preparing a paper on a subject so broad and important as that comprehended by the above title, the authors soon came to a realization of the fact that volumes could be written and still there would be much left unsaid. We were not unmindful of our lack of detailed knowledge of the production problems of the iron and steel industry, but we have tried to sketch in the mutual relationships from the standpoint of power production. To assist us in visualizing the problem from your angle we have called upon a number of authorities in the steel industry and we acknowledge our debt to Mr. S. S. Wales of the Carnegie Steel Company, to Mr. Barton R. Shover, consulting engineer, and to Mr. W. B. Skinkle of the National Tube Company for their valuable assistance and advice.

Interconnection between the electric power systems of the larger steel companies and those of neighboring electric utility companies seems to be inevitable. In fact, the companies which the authors represent already have a total of 245 connections with the iron and steel industries in their chartered territory, which includes practically all of Southwestern Pennsylvania, Northwestern West Virginia and of the so-called Pittsburgh district. The sum of the power demands of these installations has already reached the considerable total of 91,029 kw.

This total is, however, relatively small as compared with the power-consuming capacity of the steel industry. From Mr. Barton Shover's paper read before this convention, we quote a figure of 4,440,000,000 kwh. required for the 1922 production of iron and steel, which is equivalent to a 15-minute maximum demand of approximately 1,000,000 kw. These figures assume the application of electric power wherever possible as being the most efficient form of drive available. Present conditions with only a comparatively small percentage of electric drive in use requires prime mover and boiler capacity far in excess of the figure above named.

It is not within the province of this paper to discuss the relative efficiency of steam and electric drive and it is further believed that we may take for granted, particularly before the Association of Iron & Steel Electrical Engineers, the superiority of electric drive. Table IX of Mr. Shover's paper shows in the 10-year from 1909 to 1919 that while the total primary power increased 66 per cent from 3,354,513-hp. to 5,577,-584-hp., the electric power increased 211 per cent from 871,723-hp. to 2,712,774-hp. In other words, the increase in total primary power came almost entirely through the medium of electrification; 1,841,051-hp. of the 2,223,071-hp. total increase, or 82.7 per cent, was from this source. With such an overwhelming trend toward the application of electric power it would be a waste of time and effort to detail the manifest preference for this type of drive.

The conversion of coal to coke and ore to iron produces sufficient energy, if properly utilized, to roll and finish practically all the iron and steel produced. Mr. Shover's paper states that considering the entire steel industry in 1922, the total coal equivalent of the waste heat produced was 22,857,578 tons, as against a requirement for rolling and finishing and other power purposes in the steel mills of only 16,705,485 tons. In other words, if the steel industry had utilized all of its by-product heat under high efficiency boilers to produce electrical energy in large turbo generators, and had applied the energy to motorized mills, the surplus available for other purposes would have been equivalent to 6,152,093 tons of coal, a saving well worth considering.

The sources of waste heat in a steel mill are available 24 hours in the day. When furnaces are being tapped there is a momentary drop in the gas available, but where there are several furnaces in operation in a given plant, the resulting output curve is very uniform. In a mill properly balanced as to finishing departments, as compared with blast furnaces and open hearths, there is a marked difference in the characteristic curve of the energy which can be produced from by-product heat and the energy required by the mill. This is due to the fact that the mills are practically shut down over the week-end and there is little or no requirement for power, whereas blast furnace operations continue uninterruptedly. This difference is graphically shown on Chart No. 1. This condition results in the present practice, in steel mills equipped for utilizing by-product heat, of wasting heat because there is no available disposition for the electrical energy which could otherwise be produced.

An even balance between the blast furnace and rolling department of mills is seldom attained in prac-

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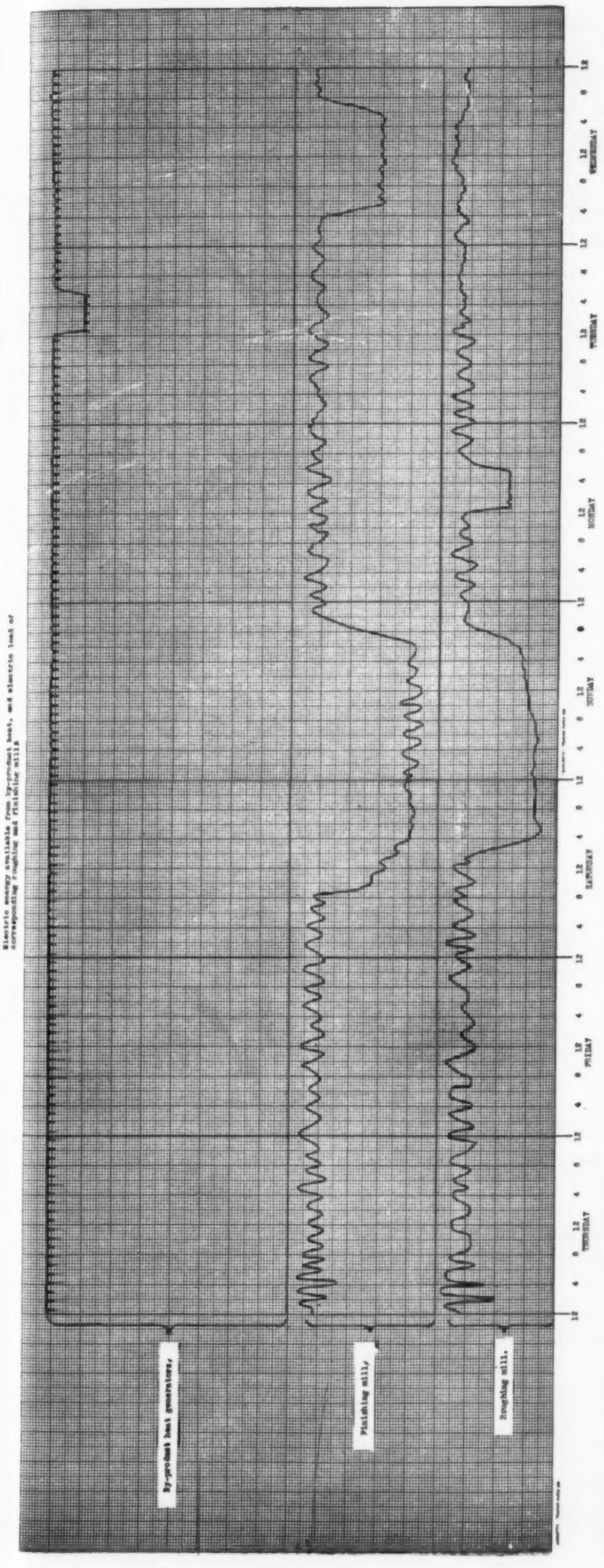

CHART I

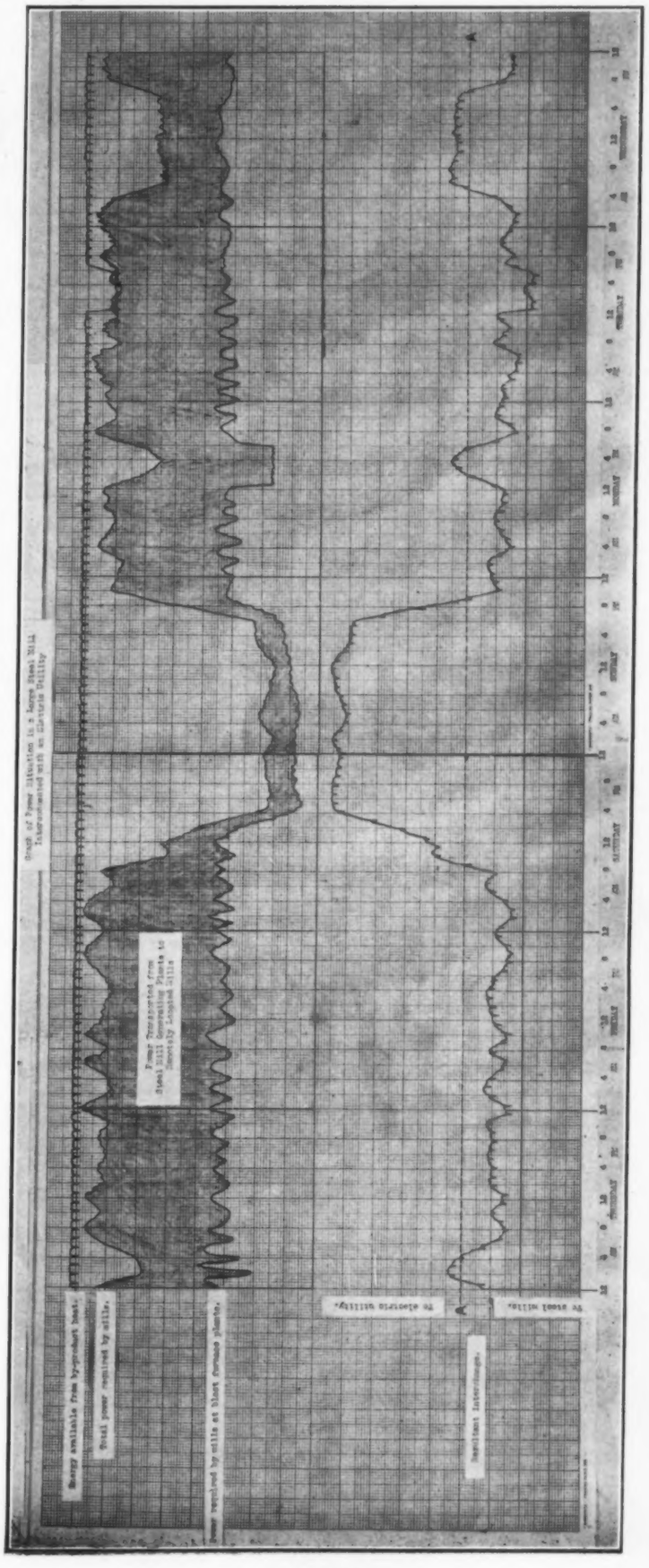
Energy available from by-product heat.
Total power required by mills.
Power transported from Steel Mill Generating Plants to Heavily Loaded Mills
Power supplied by mills at blast furnace plants.
To steel mills.
To electric utility.
Resultant interchange.

CHART III

tice and many mills are found with blast furnaces in one location and rolling mills at some other location, a condition which does not produce the proper balance between energy-producing and energy-consuming equipment. The larger steel companies have already found it desirable to connect their various mills by means of transmission lines in order to take full advantage of energy available from by-product heat by distributing it to those plants where there is a deficiency of power producing equipment.

Considering the difference in the load characteristics of the blast furnace and rolling departments, and the difficulty of properly balancing these two elements of steel mill power systems, it has, heretofore, been impossible to completely utilize the waste heat available. From an economic point of view it seems logical that some way will be found to interconnect the steel mill power systems with some reservoir which can absorb their output over periods when the available power is not required for mill purposes. The large electric utility systems offer a splendid opportunity for so doing, and the sooner these facts are faced the sooner will these two basic industries get together to their mutual advantage.

Advantages to Steel Industry.

When the obvious advantages of such interconnections are considered it is surprising to note how little progress has been made toward this end. For the steel industry interconnection will result in a reduction of investment in standby generating and transmission systems for the reason that the electric utilities standby equipment will be available to meet any untoward emergency which may develop, and their network of transmission lines will provide a reliable means of transporting power.

Interconnection will result in the elimination of vent losses over week-ends and holidays. No accurate figures are available to indicate which percentage of the waste heat energy is lost in this manner, but it it conceivable that it may be of the order of 5 to 10 per cent and represents a huge waste of coal.

Interconnected with a comprehensive system of transmission and distribution, additional coal-burning boilers solely for producing power should be unnecessary and it would be possible for the steel industry to devote its funds to a more complete utilization of waste heat and to the further electrification of its mills, resulting in greater economies in operation.

It is difficult to arouse interest in conserving a natural resource as plentiful as the splendid bituminous coking coal in Western Pennsylvania. These resources are limited, however, and there is little to excuse our wasting this valuable resource because we are not willing to completely utilize the energy in the coal which is consumed in the preparation of coke and in the conversion of ore. Most of the large steel companies have their own coal reserves and it should be possible to place a very tangible value upon the increased life of these resources due to the more complete utilization of the fuel. It follows without question that more complete utilization of waste heat and the application of power for driving rolls by means of electric motors will reduce the cost of making iron and steel.

Finally, there is an advantage to the steel industry which is perhaps a little harder for them to appreciate and to evaluate on account of the fact that up to the present time the problem has not presented itself in a particularly acute manner. If both the steel companies and the electric utilities are to build their own transmission lines between the various energy-producing and consuming centers, it will result in a duplication of investment and an increased number of transmission lines which will present increasingly difficult right-of-way problems.

Advantages to Electric Utilities.

It follows that those things which are advantageous to the steel industry are also advantageous to the electric utility industry. It is necessary in modern, well-operated central station companies to have spare generator capacity available for emergencies and so that equipment can be taken out of service for repairs and for regular maintenance and inspection. At the present time the practice is to do maintenance

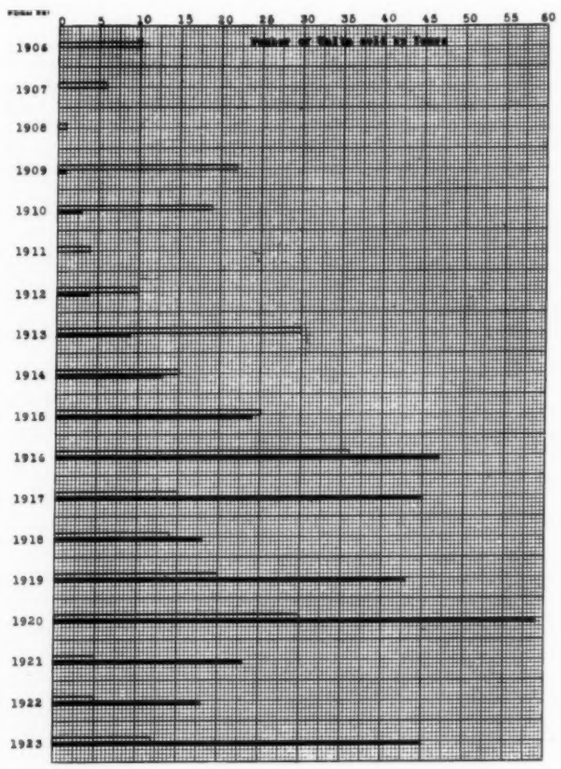

CHART II

work on week-ends and on holidays when the load is lighter than during the week. With an outside source of power available on Saturdays and Sundays, the margin between the load carried by the central station equipment and the prime mover capacity necessary in central station plants could be safely reduced. This would also effect transmission lines, particularly because an interconnection with the steel mill would in all probability be a point toward which central station power would flow during the week, whereas over Saturday and Sunday the direction of power flow might be completely reversed. In other words those lines adjacent to the central station generating plant would be more available for maintenance work over the week-end if the source of energy over Saturday and Sunday were in a different location and adjacent to the load centers.

Electrical energy generated from by-product heat represents an additional source of low cost energy for the central station company, and while it is only available to the central station company at times when its own costs are very low, nevertheless it can probably be sold to the central station company at a profit to the steel mills, but still at a figure below the production costs in the central station plant.

Interconnection would assist the central station companies in their right-of-way problems as it would tend to reduce the number of transmission lines spread across the country.

As was pointed out previously, the steel mills of the country are not all balanced as to energy-producing and consuming equipment and further, the load curve of these two classes of equipment in the steel mill is radically different. It is therefore, probable that the economic solution of this problem would demand that a certain part of the load of the steel mills be supplied by the electric utilities. Even though the load were properly balanced in an individual mill, it is probable that the steps in the development of the plant would result in its first being overbalanced for a period on the side of the generating equipment and at other times on the side of motorized rolling departments. This in itself would mean that for periods, at least, the central station company might be called upon to supply a part of the power requirements of the mills.

Advantages to Public.

The public utilities are alive to the fact that whatever is in the interest of the general public is to their own interest and there is no question but that the adoption of a policy of interconnection on the part of the central station company which would result in the conservation of natural resources, would lead to better public relations by clearly establishing the fundamentally sound principles on which the central station business is being conducted.

It is estimated that the saving in coal during the year 1922, which has been referred to, would have been sufficient in itself to have supplied the entire coal requirement of the country for domestic heating purposes. It would also release to other uses a great amount of railroad equipment now tied up in the transportation of coal. The complete utilization of by-product energy would result in the elimination of a great deal of coal-burning equipment in the steel mills and tend to abate considerably the smoke nuisance which is so prevalent in industrial districts.

Finally, the public is always interested in any movement in the direction of lower costs and there is promise in the interconnection between the central station and steel industries of lower costs to both industries.

Difficulties to Be Overcome.

The difficulties in the way of interconnection between the electric utilities and the steel industry do not appear to be insurmountable when carefully analyzed and evaluated. At least one of the difficulties is largely a mental hazard. This is the prejudice which exists to some extent among steel mill engineers against central station service. Those familiar with steel mill operation thoroughly appreciate the exacting requirements of this industry for continuous power service. The standards of construction of the large electric utilities are of the highest order and the lessons taught by their daily operating experience are rapidly eliminating the interruptions to overhead transmission lines. Duplicate transmission lines over separate routes are gradually being built and provided with sectionalizing and protective equipment at strategic locations.

It is reasonable to expect that with such modern facilities and practices, service can be delivered over overhead transmission lines at the higher voltages which will be necessary for the distances to be covered, which will compare favorably in performance with the best operation of any of the steel mill power systems. The interconnection and successful parallel operation of such large units of production as are represented by the modern electric utility system has been a problem in itself of no mean importance. The fact that it has been solved by the central station companies leads them to look forward confidently to substantial interconnections with the steel industry with the knowledge that the problems which will be introduced by such interconnections have already been solved on their own systems.

Another obstacle which has frequently stood in the way of negotiations between central station companies and the steel mills has been the comparison between the cost of delivering electric service from the steel mill plant and from the electric utility. The smaller central station companies have not been in a position to offer low rates for the large blocks of energy which the steel mills require, but the larger power companies have rates which on load factors comparable to those developed by the steel industry will produce net rates of approximately 1 cent per kwh. There is a tendency on the part of the steel mill engineers to consider only the best performances of their equipment, instead of the average experience and to overlook some of the overhead and fixed costs properly chargeable to power production. These factors we have referred to as mental hazards because they are rapidly being overcome and the functioning of associations such as this body have resulted in a much better understanding of the various aspects of this problem, both by the steel mill and the central station engineers.

The difference in generator frequencies employed by steel mills and neighboring central companies in some localities represents one of the greatest difficulties to be overcome in the interconnecting of the electrical transmission systems of these two basic industries. In the early days the performance of electrical equipment available led to the thorough entrenchment of 25-cycle systems in steel mills. 60-cycle mill equipment has now been developed to the point where it is thoroughly reliable and in most cases equally as efficient as the 25-cycle equipment. It is interesting to examine the trend of equipment sales to the steel industry itself and we have prepared a chart to show the number of main roll drives of both 25 and 60 cycles sold by the two largest electrical manufacturers from 1906 to date.

Referring to Chart No. 2 it will be noted that the sale of 60-cycle main roll motors did not begin until 1909 and were hardly worth mentioning until 1913, in which year nine 60-cycle mill drives were furnished, as compared with 29 of the 25-cycle type. In 1914 and 1915 the sale of 60-cycle equipment equalled that of the 25-cycle type and has exceeded it every year

thereafter. In 1923 there were only 12—25-cycle equipments sold as against 45 of the 60-cycle type, a ratio of almost 4 to 1. This chart, of course, does not take into consideration the sale of motors in mills where 25-cycle equipment already predominated, and there is not much doubt but that if this important influence was eliminated the predominance of 60-cycle sales at the present time would be even more marked than as indicated by the sales in 1923. We feel that the frequency problem is not as serious as it has heretofore been regarded. The satisfactory performance of 60-cycle mill equipment and the reliability of central station service make it impossible to make 60-cycle installations in mills where the present power supply is 25 cycles. The 60-cycle equipment can be operated by central station power until such time as motor-generator sets have been installed to provide a duplication of service to the new 60-cycle mills and to make possible further utilization of the energy developed from by-product heat.

Another difficulty which presents itself is the development of an equitable basis for metering and billing. Interconnection between central stations and steel mills which produce the major portion of their electrical energy will involve the metering of energy transmitted in two directions, and must further take account of the fact that energy delivered at certain times has a higher cost and value than energy delivered at others. It is quite conceivable that this will require the totalizing of meter registration at one or more points of interconnection. Within recent years electrical manufacturers have developed devices whereby any number of meter registrations can be totalized at some remote point, and we believe that the necessary metering equipment has been developed in order to satisfactorily solve this problem.

In conclusion it is apparent that this problem huge and difficult as it may seem at first glance can be solved to the mutual advantage of the interested parties. Interconnection, in order to utilize the waste heat or the iron and steel industry, is economically sound and of paramount importance. Interconnection, in order to conserve investment in plants and lines of both parties is equally in line with progressive thought. In the light of recent developments in super-power systems, the objections to parallel operation and distrust of central station service seem more fancied than real. It is hoped that the next few years will witness some long strides forward toward this goal.

Machine Tools and Their Auxiliaries in the Steel Mills

(Continued from page 482)

By the grinding process the necks or journals and the roll face are concentric with each other within very close limits which results in a material saving in babbitt and bearing repairs. The exact amount of this saving cannot be determined but it is reported to be quite a factor in large plate mills.

Fig. 20 shows a general view of a roll grinding machine. The machine shown swings rolls up to 54 in. diameter and takes 14 ft. between centers. Other machines of this design have been made to take rolls up to 28 ft. in length. The weight of the 14-ft. machine is about 50 tons. Rolls are revolved in massive journal bearings and the grinding is done by wheels 24 in. diameter by six inches face with provision made for forming the corners so that the fillets in the roll necks where the neck and body join may be ground. A forming bar is incorporated which is adjustable by hand wheels to produce accurately any desired curvature on the roll face.

Four motors are required to operate the machine all controlled by push button stations on the operator's platform. The wheel carriage is traversed and the grinding wheel rotated by a 40 h.p. motor. The headstock mounts a 20 h.p. motor which rotates the roll, this is a variable speed motor with a controller convenient to the operator, as shown in Fig. 21. The footstock is provided with a 2 h.p. motor for running it along the bed and a 2 h.p. vertical motor, also shown in Fig. 21, is mounted on the wheel carriage for driving the lubricant pump and moving the wheel slide to and from the work.

The grinding of rolls for cold rolling presents quite a different problem from that of dressing rolls used in hot mills. With cold rolling finish and accuracy are of prime importance. The quality of the surface on the rolled product depends entirely on the finish on the roll surface as each mark or scratch is reproduced in the product.

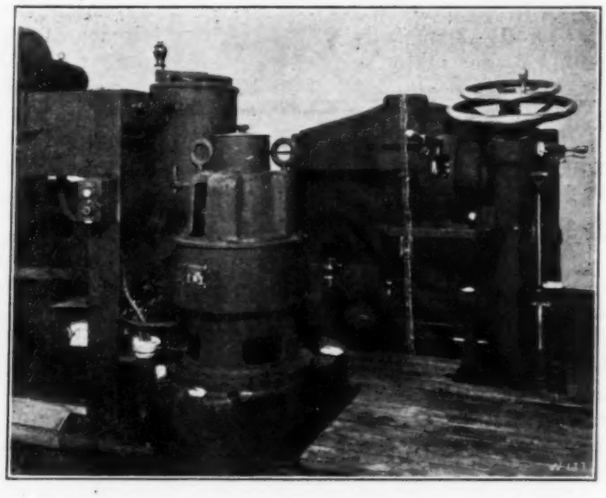

FIG. 21

Grinding in some form has long been used for making such rolls serviceable after they have become worn by use in the mills but until recently practically all such rolls were lapped or polished subsequent to the grinding operation. The most up to date method is to combine the grinding to size and polishing operations by a rough and finish grinding in the same machine. The desired reflecting finish free from scratches is obtained by a fine grained wheel and by using only clear water on the roll which passes over the wheel and work but once. Careful tests have been made using both ground and lapped rolls and it is reported that rolls finished in the grinding machine because of their greater accuracy remain longer in service before requiring regrinding and produce just as good a product.

Rolls used for the production of foil and flat wire are usually made of hardened steel and require a mirror finish. Machines such as are shown in Fig. 22 are used to grind this class of rolls as well as many chilled iron rolls within their capacities.

A similar machine, as shown in Fig. 22, swings 14 in. and takes 50 in. between centers. It is provided with a forming attachment for crowning rolls and is self contained, being driven by one motor on the floor at the rear of the base.

Fig. 22 shows a larger machine for rolls up to 20 in. diameter. The total length between centers is

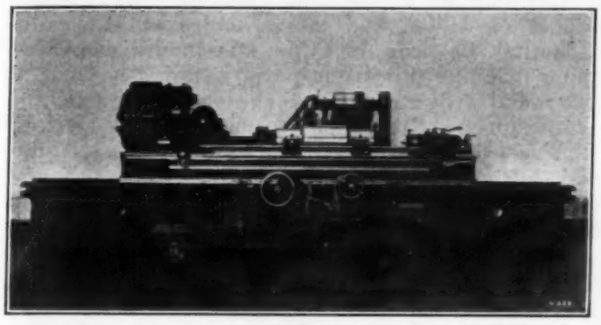

FIG. 22

96 in. and the machine as shown is provided with journal rests and a wabbler drive. The machine is wholly self contained without any overhead works. The headstock which rotates the roll is driven by a three h.p. motor with control on front of base and the table traverse and grinding wheel are driven by a 25 hp. motor on the floor at the rear. This type is built in swings up to 26 in. and any length required from 96 in. up.

Other grinding machines which find a place in the machine shops of steel mills are those used in the making and maintenance of special tools, guages, etc. Among such machines the universal tool and cutter grinding machine, shown in Fig. 23, is in most demand. It is built in two sizes the one shown being the larger, and is provided with attachments which are easily adjusted for the various operations necessary in the grinding of milling cutters, reamers, counterbores, taps, end mills and arbors as well as for light internal, cylindrical and surface grinding.

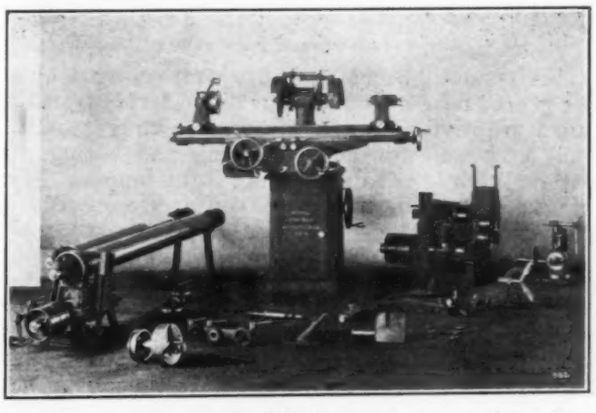

FIG. 23

The multipurpose grinding machine is a self-contained universal machine in which are incorporated many unique features which make it convenient to operate, very accurate in its adjustments and to require a minimum of care and expense for maintenance. In the small repair shop it will handle all the internal and cylindrical grinding and perform many special operations on tools, dies and cutters.

The Type G, 6 x 10 x 36 in. open side surface grinding machine is perhaps not as necessary to the average steel mill, but where many dies are made is very useful as well as for surface grinding af parts for tools and fixtures. A magnetic chuck is usually employed for holding the work. The machine is self contained and driven by a 15 h.p. motor mounted on the base of the machine.

BORING MILLS*

Fig. 24 is a 54-in. boring mill and the manufacturer's claims for this are as follows:

Materials.

Properly speaking, the subject of materials is a sub-division of the factor of design, i. e., the materials to be used are always specified with the latter. It is not ordinarily considered as separable from the question of design, chiefly for the reason that an amount

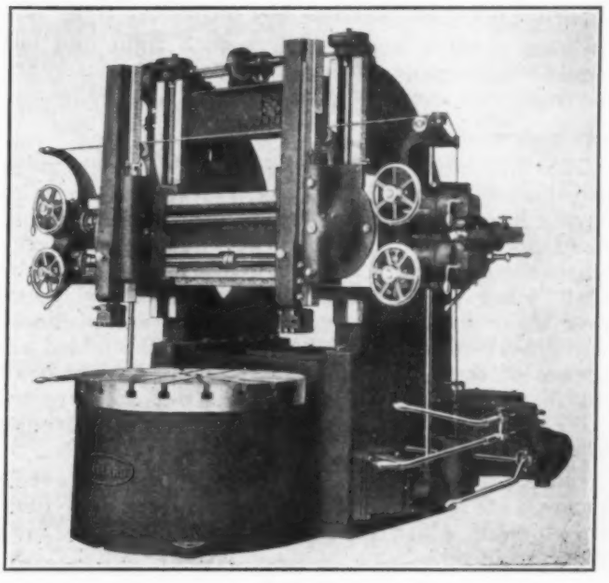

FIG. 24

of attention consistent with its importance has not been given to the subject hitherto.

With the advent of alloy steels and their common use, particularly in automobile construction, machine-tool builders were called upon to build tools that would stand the greatly increased stresses of cutting such materials. Machine tools were accordingly made heavier without any departure from the materials commonly employed.

Increased proportion of parts, with added weight, is not wholly effective, however, particularly in such items as gears, shafts and similar parts required to transmit the greater power loads and withstand the conditions of usage now imposed. Further, production demands called for construction embodying the highest convenience and ease of manipulation, and this, also indicated a change in material which would permit a reduction in size and weight of parts without sacrifice, but rather an increase, of strength.

Realizing these facts fully, this company was accordingly a pioneer in the adoption of alloy steels of the highest grade for all parts called upon to

*Contributed by Bullard Machine Tool Company.

carry the major stresses of power and feed transmission. Superior facilities for the scientific heat treatment of these materials are an important part of our plant equipment.

It is highly consistent with this company's policy that the final selection and adoption of any material is dependent on its demonstration of superior merit in actual and continued service.

The driving units, of familiar sliding-gear and positive clutch type, serve also as speed-change mechanism. Gearing and shafts throughout are of high-quality alloy steel, hardened and heat-treated to withstand most severe service, all encased in units providing a maximum support for shafts to obviate deflection, torsion and consequent misapplication of power.

The table driving gear is a forging of alloy steel of such proportion and composition, heat-treated before machining, as to give maximum strength and wearing qualities at this point. Its mating pinion is supported between bearings of exceptional area.

Power control is provided at both right and left sides of the machine and is simply, yet adequately interlocked with speed control.

Lubrication.

The lubrication of working parts has been given most thorough attention—the primary object being an increase in productive capacity by an insurance of continued operation at high efficiency in power delivery and by the elimination of time-losses incidental to the usual "oiling-up" process. Longer life of all parts, lower maintenance charges, and a constant readiness for the heaviest work are but a few of the added advantage of the continuous flow system, in which all units having a fixed relation to the bed are supplied with clean, filtered oil at all times while main driving pulley is in motion.

Other units, such as feed-works, power traverse brackets, etc., mounted on crossrail, form individual reservoirs in which gears and shafts are constantly immersed in oil.

Accuracy.

To produce accurate work a machine must be originally accurate. To obtain original accuracy the processes and equipment of its manufacture must be of a like high order.

Power.

The source of power is, and should be, ample and unvarying. A constant-speed pulley of large dimensions provides for connection to either motor or main line shaft. Interposed between it and the speed-change units is a well-proportioned clutch of the multiple-disc type, which permits of instant application or stoppage of power, and in connection with which is incorporated a quick-acting brake for stopping the table.

RADIAL DRILL*

Fig. 25 is a 5-ft. triple purpose radial drill with plain arm. This triple purpose radial is supposed to mark one of the great advances in radial drill design, because, not only has the design of the general working parts been materially improved, but what is of much greater moment a new function or purpose has been added to the radial drills field of operation — hence its name.

*Contributed by American Tool Works.

In the past the radial has been devoted to drilling and tapping. The third function of this machine is boring.

The manufacturer of this machine in placing so much emphasis upon this new function does not wish to detract in any degree from the drilling and tapping qualities of this machine. As a matter of fact, this new radial is without question the greatest producer of drilled and tapped holes of any radial drill built. To bear out this statement, we direct tapping machine this triple purpose radial is what no other radial drill can claim to be—a boring machine. In consequence, this machine will not only perform to the very best advantage the work of the standard radial, but will do boring operations efficiently and economically that heretofore could not be handled on a radial drill.

It therefore follows that by installing the new triple purpose radial the purchaser will obtain a machine which will not only perform all of the work expected of an ordinary radial drill, but will in addition handle work that no other radial can.

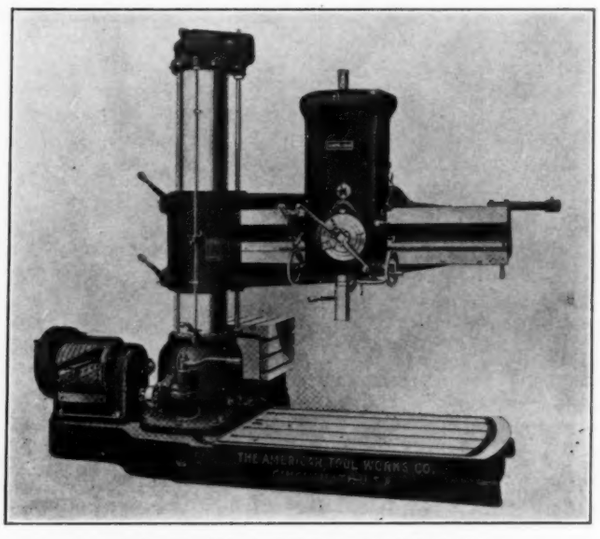

FIG. 25—*Triple Purpose Radial Drill.*

This result is accomplished by providing a quadruple geared head affording four distinct speeds, which in turn are divided into two separate ranges of two speeds each, one for heavy tapping and boring, the other for high speed drilling and light tapping. The boring and tapping range in conjunction with the eight-gear box speeds comprise 16 speeds from 17.5 to 95.5 r.p.m., which are obtained through an internal gear drive on the spindle, while the high speed drilling range consists of 16 speeds from 107 to 575 r.p.m., obtained through an external gear drive, the internal and external gear drives being non-interfering. These 32 spindle speeds are in geometrical progression, and cover a wider and more useful range than is provided by any other standard radial drill.

In developing this new radial every part has been strengthened, improved, and made more serviceable and productive. There are some special features, however, that we shall call particular attention to by enumeration.

1. Power—15 h.p. delivered to speed box.
2. Quadruple geared head—32 speeds.
3. Internal gear drive.

4. Improved ball bearing tapping attachment —runs in oil.
5. Simplicity and convenience.
6. Material.
7. Centralized lubrication.
8. Counterweight construction—danger eliminated.
9. Feeding mechanism—8 feeds on one dial.
10. Improved arm construction—spring greatly reduced.
11. Elevating mechanism—fool proof.
12. Speed box—improved.

The Practical Essentials of a Radial Drill to Meet Present Day Requirements.

The arm, column and base must be of rugged, well braced design to meet the requirements of high speed drills, but no matter how heavy these members are

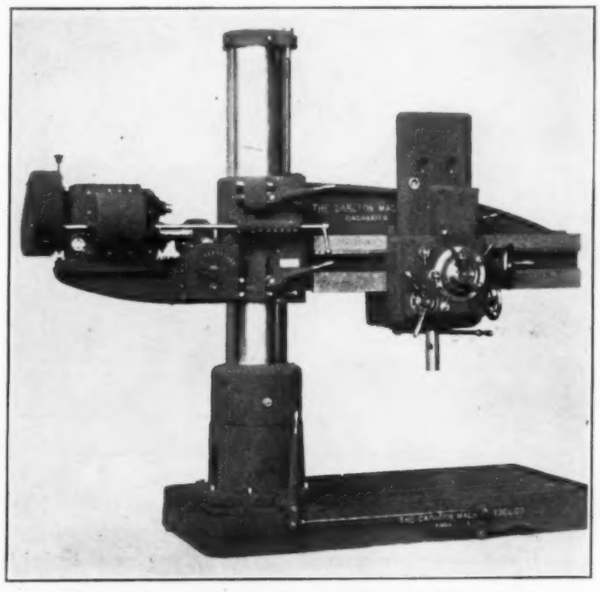

FIG. 26—*A modern type of radial drill.*

made, there always is a certain amount of deflection owing to the inherent design of a machine of this type.

The round column type machine has the advantage of greater drilling radius and further results in a firmer tie between arm and column.

The fact that rigidity being very essential the next necessary step is convenience of operation so that machine can be manipulated with but little effort and not prove to be a "man-killer," and this condition can be best obtained by the use of large size roller and ball bearings properly suspended and running in an oil bath if possible.

The design of the spindle head is most important, as same should be in perfect balance on the ways of the arm, which allows head to move freely without cramping action and further maintains more perfect spindle alignment.

To further insure greater mechanical efficiency it is very desirable to carry spindle driving mitres in separate cages so that these mitres can also be carried on ball bearings and fully enclosed to run in a bath of oil, and by using driving shafts with multiple keys integral with shaft it greatly increases their strength, durability and efficiency of drive, and particularly by employing the lathe headstock drive to the spindle, in which case the power would be applied to the lower end of the spindle nearest to the cutting tool, insuring a more steady drive.

It is most desirable that all spindle driving gears be made from steel hardened running in a bath of oil and preferably forced feed lubrication, particularly for the gears in the spindle head.

The usual type of expanding or contracting friction rings for spindle reverse should be changed and something of a more practical design substituted, for example, multiple disc frictions, which have proven so satisfactory in automobile practice.

There is a diversity of opinion relative to having motor at base of column, or on rear end of arm; this is entirely governed by the whims of the purchaser for the reason that with a properly designed and built machine there is hardly any noticeable difference in the mechanical efficiency of both types, but in the manipulation of the machine with the motor on the end of the arm, same has a number of disadvantages, the principal one being the increased inertia brought about by the additional weight of the motor on the end of the arm, requiring somewhat more effort to start arm and particularly to stop arm at a given point.

There should further be given due consideration in the design of the machine to the use of either variable speed d.c. motors or constant speed a.c. motors, in which case a gear box must be provided, and same should also carry hardened steel gears which should run in a bath of oil.

The general belief among users is that a machine built on the foregoing lines will meet present day requirements, and the claims of the twist drill manufacturers.

AUTOMATIC CONTROL OF MACHINE TOOLS*

A machine tool must not merely be started and stopped; it should be started precisely at the right time, under perfect control, and should be stopped exactly as you want it, and stay stopped until it is again started. The machine tool should do the work; the operator should use his energy solely in directing it. He should not be called upon to spend his valuable time, or his mental energy in operating an oil

*Contributed by Electric Controller & Mfg. Company.

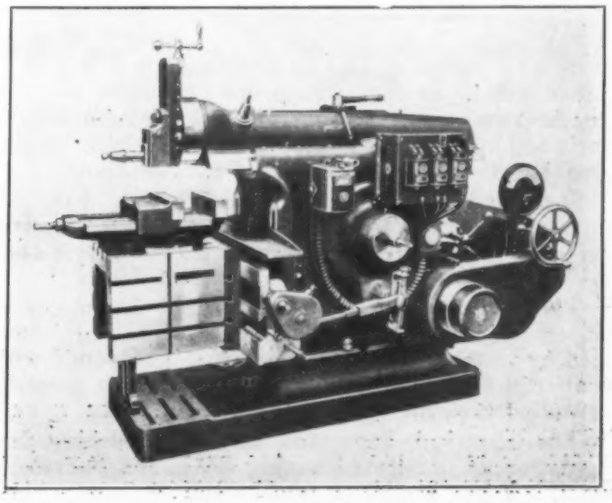

FIG. 27—*Shaper with automatic controller providing starting and stopping by dynamic braking.*

can on 60 or 100 different holes which are supposed to be oiled. He should not be called upon to shift dangerous belts or move heavy parts. We can do all of these things by power.

There is absolutely no occasion today for an operator to be required to do these things, and any machine which compels the operator to use his physical energy to move heavy parts, to shift belts, or do any of the things which waste time and productive energy, is inefficient in design and construction.

What, then, are the essentials of machine tool design? The things that we can lay down and say we must have. It seems reasonable that we should ask for productability, the ability to produce. It is of prime importance, for it is what we buy the machine for, and if we cannot get productability we have not spent our money wisely. Thus, productability is the first essential.

We have already spoken of the starting and stopping, and wish to impress upon you the importance of that detail. We believe the starting and stopping of a machine are, possibly, the most important functions of the operating mechanism. The machine should start just when the operator wants it to. It should not start a little ahead of time and it should not lag. It ought to stop just as exactly as you stop an automobile, a trolley car, or any other moving object.

The starting and stopping of any machine are two very important factors in its operation. Shifting belts do not meet the new conditions; they are too slow. Efficient clutches are difficult to make. In fact, we think the weak point in about 90 per cent of the automobiles is in the clutch. The clutch does not work, it starts too quickly or it drags. Some of you probably drive automobiles and you know that the clutch is a

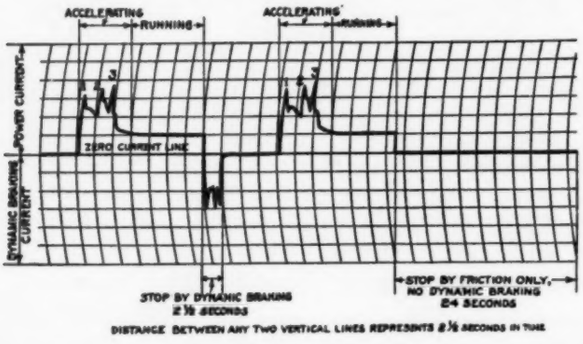

FIG. 28—*Chart showing the difference in time when stopping dynamically and by friction.*

very important part of your machine. A clutch in a machine tool is equally important. It cannot be too good, and the brake merits equal consideration.

So far it has been attempted to prove:

First—That control is a large factor in securing increased output per machine. In short, "motor control" is not less important than "motor drive."

The shunt wound, adjustable speed d.c. motor is not, in itself, an accommodating machine, but regulated by suitable electrical apparatus, it responds with wonderful flexibility to the requirements of a properly controlled machine.

The electrical apparatus for accomplishing this regulation is illustrated in Fig. 29. The operator's switch, Figs. 1 and 2, establishes different electrical connections, for starting, stopping or reversing the motor and may be worked directly by the handle or in cases where the operator's switch cannot be conveniently mounted near the workman, mechanical connections may be made between the workman and the switch by gears, chains, spline shafts etc.

The accelerating unit, Fig. 3, automatically starts, reverses, or stops the motor with current limit protection at all times. For years, the advantages of

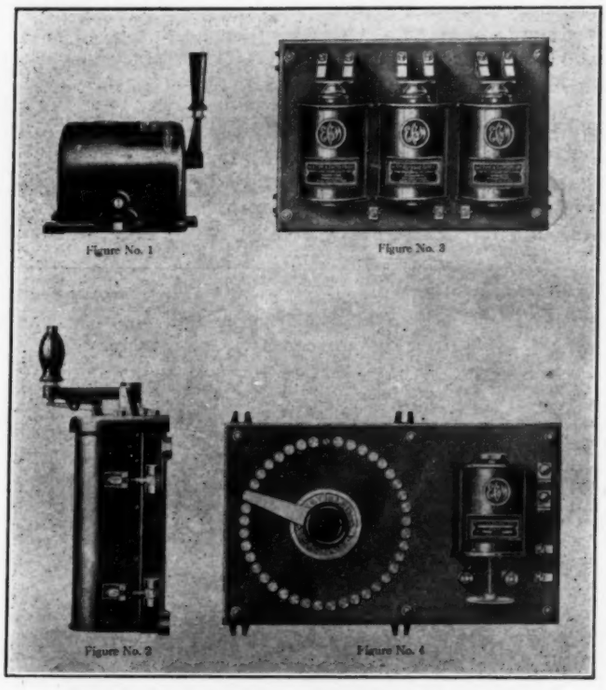

FIG. 29—*Automatic control for machine tools.*

controlling motors by automatic magnetic switch apparatus, have been freely admitted in such diverse applications as electric traction, elevators, and notably in the case of the enormous machinery of the iron and steel industry. Automatic control of a motor provides the limitation of the starting, reversing or stopping current to a safe, predetermined maximum value; it starts, reverses or stops the motor in the shortest, safe amount of time; by limiting the starting, reversing and stopping currents, it protects the motor from shorts, grounds and commutation troubles, and limits the torque in the motor and driven machine. All these and other advantages of automatic magnetic switch control are well recognized, but it is the aim of this paper to discuss only such features as relate to increased production of machinery.

In addition to the operator's switch and accelerating unit, a field rheostat relay, Fig. 4, is frequently used.

As to just what this system of control provides, the following items should be given prominence:

First—The motor is started from rest and attains the speed corresponding to the setting of the field rheostat, in the briefest amount of time which is safe and with the motor current maintained within safe limits. This limitation of current applies not only to the part of the acceleration due to the removal of the resistance in series with the armature, but equally to the portion of acceleration caused by the weakening of the shunt field. Most important of all, this operation is accomplished—so far as the workman is con-

cerned—by merely pushing a button or throwing a small hand lever in a certain direction.

Second—The motor is reversed in the same manner and with the same automatic protection.

Third—The motor is stopped by temporarily converting it into a generator, this action being commonly designated "dynamic braking." The stopping is automatically accomplished in the shortest safe amount of time, by merely pushing a button or throwing a hand lever.

In addition to the advantages inuring from the physical acts of properly starting, stopping and reversing the motor, there is the exceedingly important psychological advantage of relieving the operator from the worry and mental exertion necessary to regulate a motor by a controller which is not automatic.

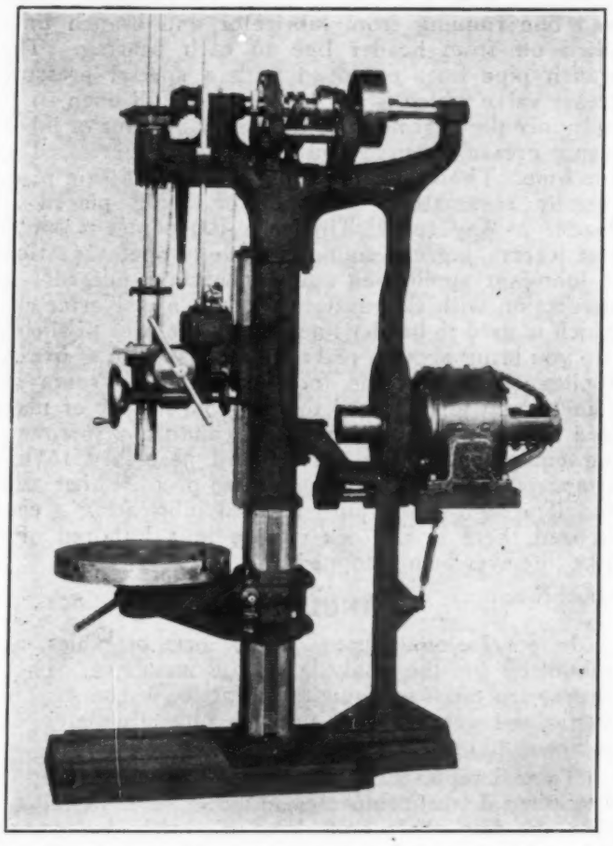

FIG. 30—24-*in upright drilling machine with adjustable speed motors.*

The workman will hardly ever move the controller handle just fast enough throughout its entire range. Mostly likely he will overspeed it several times with disastrous results and thereafter will play safe, losing time which should be devoted to his real work. The automatic controller does the thinking for the workman, not only giving him the fastest safe results, but leaving his entire mental and nervous vitality for the job he is expected to do. It is not too much to expect that this automatic control will, in numerous cases, permit the employment of cheaper labor. In fact, this has actually happened in several instances. Another feature of an analagous nature is the precision of starting and stopping afforded by automatic control. The machine can be started and stopped just as the workman plans it should, and these operations can be counted upon to duplicate themselves with the same time element.

Besides the automatic controllers just mentioned, there is the automatic starter, for use with motor driven machines, which do not demand reversal or stopping by dynamic braking. The automatic starter provides, in the single operation of starting, the advantages secured by the automatic controller in accelerating the motor. It does not, however, permit reversal or dynamic braking.

Graphic Instruments in Machine Tool Practice.*

Graphic instruments are used in machine shops in a variety of ways, and for several purposes. In general it may be said that these are main reasons for the use of such instruments in machine shop practice:

(a) Increasing production
(b) Saving in power
(c) Detecting faults in equipment or tools
(d) Testing new machine tool equipment
(e) Time study
(f) General maintenance work
(g) Obtaining engineering data for future designs.

Increasing Production.

Anything which will enable or stimulate the operator to do a given work in less time is the thing sought. This means shortening delays, increasing cuts and cutting speeds by improving tools which do the same work with less energy expenditure.

In many shops studies are made in groups by using a graphic in the circuit of the motor driving a group of machines, analyzing the records, searching out causes of delays shown and eliminating them. The records shown in Figs. 1, 2 and 3 are from machine shops, and apply to this class of work.

It is quite difficult to make tests on individual machines when group driven, and it has been suggested (though never tried) that a special tool post, in which the pressure on the cutting tool would be imparted to a hydraulic plunger, so as to produce a pressure proportional to that on the cutting tool, would enable studies to be made using a pressure recorder.

With individually driven machines, a graphic meter in the motor circuit enables a study and analysis of operation to be made.

Saving in Power.

This amounts simply to finding where and how power is consumed which does not do useful work, and effecting a reduction in the losses. Some causes are:

(a) Excessive demand
(b) Starting up too soon
(c) Shutting motors off late
(d) Light when not needed
(e) Excessive shifting load
(f) Running idle machinery
(g) Grounds, faults and leaks
(h) Improper motor sizes

Detecting Faults in Machine Tool Equipment.

This applies especially to large machines, and to the cutting tools in mcahines of all sizes. Every improper condition of the machine or the tool is reflected in the volume of power driven and the shape of the power curve.

*Contributed by Esterline Angus Company.

Testing New Machine Tool Equipment.

It is now the practice of some machine tool builders, especially those making large special machines, to make graphic tests of each individual machine in actual operation. These records insure the application of motors of the proper size, and when compared with the standard records for machines of the class under test, any defects or imperfections show up and are discovered and corrected before shipment.

Time Study.

There has always been objection to the use of the stop watch for time study in that the operator is influenced by the fact that he knows the record is being made. By using Graphic instruments, time records can be made without the knowledge of the operator. On most individual machines this can be done by means of a meter in the motor circuit. On group driven machines, a graphic production recorder is necessary.

General Maintenance Work.

One way to prevent delays and loss of time is to make regular surveys and inspections.

Obtaining Engineering Data.

In producing new machines or building new shops, an engineer can take advantage of the data which he can obtain from his present equipment, on his own class of work, by making graphic tests.

LUBRICATION OF MACHINE TOOLS*

The methods of machine tool lubrication have progressed to such an extent that the haphazard oil can method is entirely out of date. Equipment has been developed which makes it possible to lubricate all bearings on machine tools such as tire turning lathes, vertical boring and turning mills, milling machines, power hack saws, turret lathes, etc., in a fraction of time previously consumed by use of oil can.

For years men responsible for upkeep of machine tools have been anxious to eliminate oil and oil can lubrication, and in many instances adapted oil circulating systems which only proved fairly satisfactory due to fact that in uses of oil circulating system, oil must be used which at its best is uncontrollable.

A number of executives did not think favorably of oil and oil circulating systems, adapted grease and grease cups which they soon learned had many advantages some of which are as follows:

> It is safe to say that in filling a grease cup, capacity of two ounces, that a half ounce of grease would be wasted every time cup was filled. Therefore if machine was equipped with 20 or more cups and a conservative estimate of loss of half ounce of grease per cup, it is easily to be seen many hundreds of pounds of grease would be wasted through the unnecessary loss. Another very objectionable feature to grease cups is that a man with greasy hands finds it very difficult to get threads in bonnet started properly on stem of cups and causes cross threads and in majority of cases cups are very short lived. A machine equipped with 20 or more grease cups requires very careful attention as we have learned by experiences, as it is not the grease cup which has been screwed down and forced grease into bearings that gives the most trouble, but it is the grease cup the operator has forgotten to screw down that brings about unnecessary repairs. The grease cup does not have one safety first advantage. Many times the operator is compelled to take his life in his hands every time he is compelled to screw down certain grease cups on a machine tool.

Several high pressure grease systems have been developed but many of these have their disadvantages owing to the fact that gun must be taken to bearing to supply the grease. This in itself is not a good safety first feature and many times when gun is wanted it is found it has taken legs and walked away from the job.

There has been perfected and is in service in many manufacturing plants a high pressure force feed grease lubricating system and as many as 75 bearings lubricated from one central point. A header or main feed line running from lubricator and branch lines taken off from header line to each bearing. The branch pipe lines equipped with a special pressure grease valve which is set ¼, ½, ¾ or full open so as to supply the bearing with necessary amount of lubricating grease required and all bearings lubricated at one time. The lubricator being placed in a safe place thereby eliminating the operator being placed in danger at any time. This is a 100 per cent safety first feature, a great saving is made in operator's time in lubricant application and no bearings missed. In connection with this system there is a converter cup which is used in header line and by the uses of such a cup you bring about a real automatic system of grease application to machine tool bearings. In some instances iron pipe is used to run from header or main feed line pipe but on account of conditions surrounding equipment it has been found necessary to use armoured metallic tubing or grease proof rubber hose and if a high grade pure mineral lubricating grease is used there is not one chance in a hundred of a pipe line ever being stopped up.

CONCLUSION

In conclusion, figures, in the form of tables, are submitted for the analysis of the members. These figures represent machine tool practice in the steel industry and were obtained through a questionnaire sent to about 100 shops.

Table I represents the figures obtained from quite a number of steel companies, and they seem to indicate that the line shaft belt drive is slowly but surely being supplanted by the more modern and efficient individual motor drive. The figures also show that d.c. is still the most universally used current, so far as machine tools are concerned.

Direct current adjustable speed motors seem also to be in favor. However, they do not seem to be making the headway or progress they should, in view of the fact of the many speed ranges you are able to obtain with this particular form of drive. There certainly should be no question today that the adjustable speed motor is a better proposition on a machine tool when it comes to securing the wide ranges of speeds that are required. However, the machine tool manufacturer to our mind still leans toward the use of gearing to secure the various ranges of speed.

Under control the more modern type of push-button is slowly but surely eliminating the ordinary rheostat starter, and when it is taken into consideration the small amount of upkeep in comparison be-

*Contributed by Keystone Grease Company.

tween the two forms of control — also the safety features in connection with the push-button, it will not be long until all of the steel companies have discontinued the use of rheostat starters.

In Table II it will be noted that 75 per cent of the motor failures are in connection with motors over 5 h.p.

Under machine tool delays you will also note that only 2 per cent of the delays in machine tool operations are due to motor failures. 3.5 per cent is due to control failures. It would seem to us that these figures bear out the fact that individual motor drive is the correct application for machine tools.

To the question, "What is the limited factor in your production?" the answers received indicate that the machine tool itself ranks first, cutting tool second, and the motor third.

To the question, "Does overmotoring pay?" The concensus of opinion offered in this connection was that overmotoring did pay. However, I wish to quote one of the answers:

"Generally speaking overmotoring does not pay, although in some cases the greater overload capacity obtained by overmotoring may warrant the use of larger motors. On a.c. induction motors, the use of larger motors than necessary means generally underloaded machines with poorer power factor than machines would have if proper size were used, or if load were increased. For processes where the load varies considerably, and where large loads are likely to be maintained for considerable periods, the large loads would determine the motor size, even though the motor may be underloaded a portion of the time. For intermittent loads, the size of the motor would largely be determined by a careful study of the duty cycle and may be underloaded a portion of the time."

TABLE No. I — MACHINE TOOLS

	% D. C. Motor Driven		% A. C.	% Line Shaft	%	— Control —	
	Const. Speed	Adjust. Speed	Motor Driven	Belt Driven	Rheostat Starters	% Push Button	% Elec. Master at Apron
Lathe	34.90	31.80	3.8	29.5	40.00	30.0	30.0
Boring Mill	27.90	38.90	15.2	18.8	65.00	35.0	
Planer Mech. Rev.	60.02	5.14	28.0	7.0	45.12	47.9	
Planer Elec. Rev.	46.00	39.00	11.0	4.0	40.00	60.0	
Milling Machine	16.00	12.00	30.0	42.0	30.00	65.0	
Slotter	31.20	28.30	14.8	25.7	60.00	40.0	
Gear Shaper	25.00	25.00	20.0	30.0	30.00	70.0	
Drill Presses	32.40	29.60	15.0	23.0	75.00	25.0	
Grinders	35.60	2.00	31.0	31.4	31.00	69.0	
Miscellaneous	21.70	2.00	27.0	49.3	65.00	35.0	

TABLE No. II — MACHINE TOOLS

	Per Cent
Motor Failures	
Motor driven less than 5 h.p.	25
Motor driven over 5 h.p.	75
Direct current constant speed	52
Direct current adjustable speed	34
Alternating current constant speed	14
Control Failures	
Rheostat (starter)	41
Push button starters (start and stop)	43
Adjustable speed (magnetic)	18
Machine Tool Delays	
Delays due to	
Motors	2.0
Control	3.5
Machine tool	23.7
Cutting tool	38.8
Operator	11.5
Material handling	20.5

To the question, "What methods do you use to determine whether your machine is over or under motored?"

It would seem that the best method of determining whether a machine is over or under motored is to make an actual test, reading voltage at terminals of machine, current in all lines, and power input. Also read speed of the motor. If service is intermittent or if load varies considerably, a graphic wattmeter would give the best data for power required, and from this data the power size of motors could be computed.

To the question, "What methods do you use to determine the cutting speeds with the use of high grade tool steels?"

These answers were many and varied.

One of the answers was "judgment of operator"; another by "cutting test blocks"; another, "drive machine to its fullest capacity"; another was, "run the lathe as fast as the tool will stand up without too frequent grindings and then make the cut and feed all the lathe will stand."

Another answer was the cutting speeds with the use of high grade tool steels should be determined by the maximum speed which the tool could operate for good work and, under which the tool would stand up a reasonable length of time."

No doubt the manufacturers who distribute high grade cutting steel could suggest much better answers to this question, but we solicited only those who were actually using machine tools, and believe that these answers reflect in a large measure the attitude of the operators of machine shops. There does not seem to be any particular method of determining cutting speeds in maintenance shops.

To the question, "In your opinion what is the relative importance of correct motor application, machine tool design and selection of cutting tool?"

The answers received to this question indicate that machine tool design ranked first in importance. Selection of cutting tool second, and correct motor application third.

One answer received in this connection was, that correct motor application was so easy that it really had no bearing on the subject whatever. This should make it very simple for the electrical manufacturers and probably this is one of the real reasons why there has been so little co-operation shown in the last few years between the machine tool designer and the electrical manufacturer. In the writer's own opinion, however the value of correct motor application is very important. The choice of the proper type of motor to do the particular work greatly influences the amount and

quality of production which may be obtained from a given machine. The location of the motor and control with respect to the driven machine is of great importance. The choice of the kind of drive, whether belt, chain or gear drive, is also important considering the production desired from the machine. Individually driven machines usually give higher production, and the elimination of line shafting and belts greatly improves the appearance of the plant, makes possible lighting, and in many ways given better and more production. By grouping the control devices together and locating them convenient to the operator, production may be greatly increased.

Standardization.

Very little, if any, attempt has been made to standardize machine tools; neither has there been any effort, at least it does not appear to be in evidence, where the machine tool industry and the electrical industry has co-operated to any degree which would make it possible for the user of machine tools to inter-change control panels or motors.

I have in mind a large plant which conceived the idea of pulpit control for a large number of machine tools. The pulpits were erected, the frame work for the control panels was fabricated and erected. Control panels were purchased for 50 per cent of the shop, but before the job was completed the electrical manufacturers had re-designed the control panels which made it impossible to use the material which had been fabricated for the balance of the shop.

This has not only happened in this shop, but a great many instances of this nature could be cited. Sometimes it seems almost a waste of time to try to standardize, in view of the fact that so little co-operation is extended by the manufacturers.

Safety.

To the credit of the steel industry it must be admitted that the safe guarding of machine tools has been carried out almost religiously; in fact, it is almost impossible to find any exposed gears or belts. Practically every machine tool is equipped with all the safety devices known to humankind.

However, there is still a tendency to be just a trifle delinquent in inforcing the rules for clear aisles and clean shops, and until the industry has fully realized that a maintenance shop is not a storage yard, accidents and fatalities are bound to occur. Is it not asking too much to expect the employe to be continually on the lookout for material being conveyed overhead as well as expecting him to watch for the material piled under foot?

In one large shop a violation of the safety rules makes it necessary for the violator to spend at least two days in the safety department grounding himself in the rules and regulations of the safety department.

Equipment.

Motors.

It would be our suggestion when purchasing machine tool motors to consider the following:

First—It pays to over motor.

Second—Try and confine your selections to one make of motor.

Third—Try and select a motor which you feel the manufacturer will not re-design for at least some time; also a motor which you will be able to service with spare parts on short notice without an increase in price on account of spare parts being out of production.

Control.

First—Buy the most rugged type of control.

Second—Try and confine your selection to one manufacturer.

Third—Do not buy cheap hand starters. Buy push-button.

Fourth—Keep in mind **control** is the essence of machine tool operation.

Machine Tools.

Do not let price influence your selection of a machine tool.

Be sure your foreman as well as your machine tool operator has been consulted before you make your final decision and selection.

Keep in mind what you expect the machine tool to produce for you and buy the machine tool you feel will come closest to answering these requirements. Remember, you will have to work with the machine tool you buy for at least 15 years.

In the collaboration of this paper I am deeply indebted to the following firms for their splendid co-operation and assistance:

The American Tool Works Co.
Brown & Sharpe Manufacturing Co.
Bullard Machine Tool Co.
Norton Co.
Reliance Electric & Engineering Co.
Cutler Hammer Manufacturing Co.
Electric Controller & Manufacturing Co.
Westinghouse Electric & Manufacturing Co.
General Electric Co.
The Esterline Angus Co.
Keystone Grease Co.
The Steel Industry.

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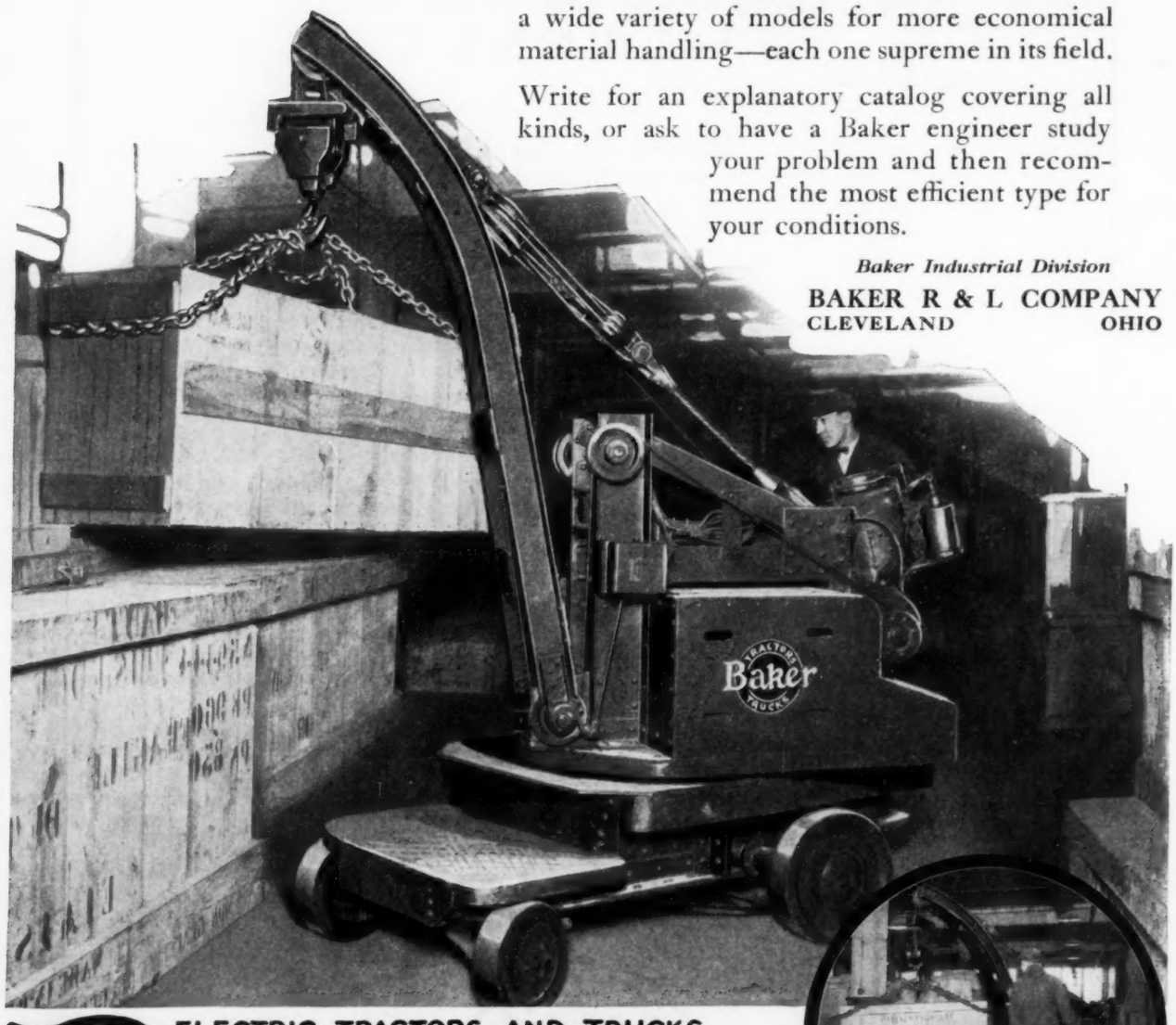

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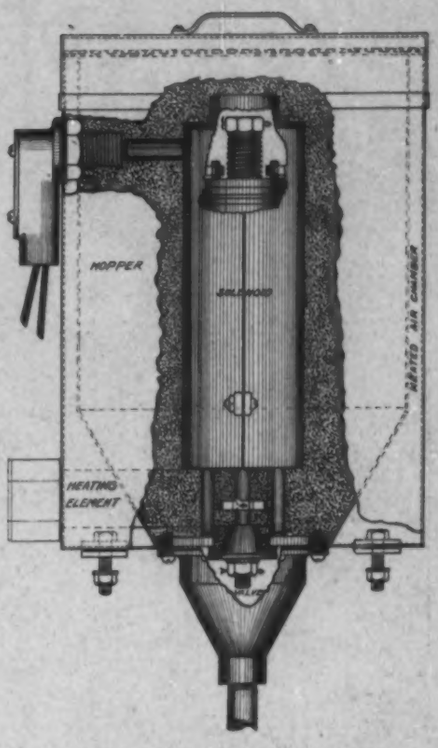
Size 12" x 12" x 17". Simple to install, substantial as to material, weatherproof in design. Study the cross-section for complete mechanics which insure positive operation. The ordinary installation calls for one sander at each end carriage—two on the trolley where the load is heavy and accurate placing is required.

The Lintern Electro Magnetic Sander

Safety—efficient and continuous crane operation—economy—these are the by-products of the new Lintern Electro Magnetic Sander. Elimination of the dangerous and wasteful hand and bucket method is accomplished and the work done more efficiently by means of a foot button *located in the cab.*



CROSS-SECTION

Even the most casual study discovers the reliability of the valve and the certainty with which the sand is directed. Note particularly the location of the heating element and the warm air chamber which provides that the condition of the sand must be such that it will respond quickly and easily.

Type "C" Operating Switch

The Sanders are operated by an N-L type "C" Momentary Contact Enclosed Switch (by hand or foot). This is located in the operating cage of the cab. When pressure is removed from the switch button, the sander valves automatically and immediately close.

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With the Lintern-Electro Magnetic Sander, wheel-spinning ceases, skidding is eliminated, and the load is delivered without delay regardless of track conditions.

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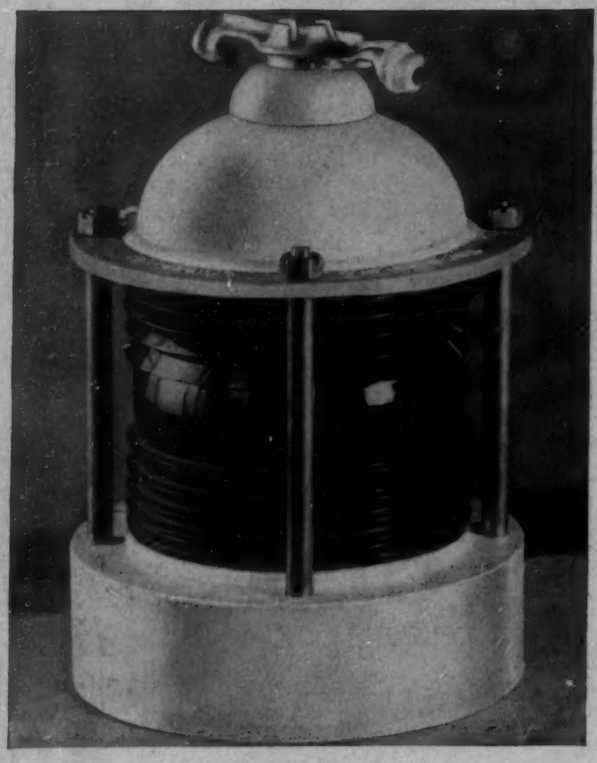

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They stand up under severest weather and

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Size, shape and weight make "Little Brother" as useful for an "exit" signal indoors as for a "warning" signal outdoors. Its weight is but 4¾ pounds and its height but 9½ inches. Equipped with 4¾" Corning Fresnel Lens in Ruby, Green, Yellow or Clear, with 4" Corning Clear Lens in base. If ground illumination is not desired, an aluminum blank may be substituted. "Little Brother" can be furnished in polished brass or aluminum.

"1-WAY"

Light-weight because it's cast aluminum—this sturdy lamp weighs but 4 pounds. Its very strength—like all the Universals, lies in its lightness—aluminum defies rust and acid atmosphere, and will not crumple under rough handling. The bulb is easily reached, but so completely enclosed that the lamp is dust, moisture and weatherproof. The lens is a 4" Corning Optical, in Ruby, Green, Yellow or Clear.

SAFETY

Universals

Signal Lanterns

the roughest handling,
most acid atmospheres

▽ ▽ ▽

For Use at

Traffic Signals
Railway Signals
Power House Signals
Building Exits, or
at any point where
there is necessity
for Danger, Caution,
or Clear Signals

"YOUNG SOL"

An adaptable lamp is "Young Sol," and of especial value where it is necessary to illuminate the ground as well as to send warning rays for some distance. The 4¾" Corning Fresnel Lens in Red, Green, Yellow or Clear takes care of the warning rays and the 16" polished aluminum reflector sends a wealth of light to the ground. Cast aluminum construction, and furnished with span wire hanger, eye bolt or ¾" pipe suspension. Weight 10 pounds.

"5-WAY"

The most versatile of the Universals. Five lens apertures allow of a variety of directional combinations, and where desired, metal blanks may be used for blocking out sides thru which light is not wanted. Its weight is but 6 pounds, due to its cast aluminum construction, and it is entirely weatherproof. The 4" Corning Optical Lenses are furnished in Ruby, Green, Yellow or Clear, and in any combination desired. Metal blanks, if wanted.

THE NICHOLS-LINTERN CO.

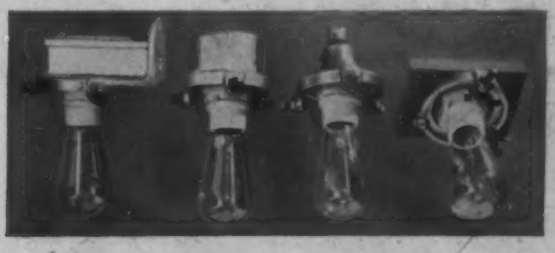
7960 LORAIN AVENUE

CLEVELAND, O.

Canadian Rep: Railway & Power Eng. Corp., Ltd. Toronto, Ont.

SALES REPRESENTATIVES:

Pharo Engineering Co., 517 Park Bldg., Pittsburgh, Pa.
F. F. Bodler, 903 Monadnock Bldg., San Francisco, Cal.
A. C. Burleigh, Little Bldg., Boston, Mass.
The Smith Equipment and Supply Co., 1011 Majestic Bldg., Detroit, Mich.



Type A	Type B	Type C	Type D
For Pole or Wall Suspension	For Open Conduit Wiring	For Pipe Suspension	For Concealed Wiring

Option of these four brackets with all Universals with the exception of "Big Boy" and "Young Sol."

N-L for SAFETY

N-L ELECTRIC SANDERS are operated by the crane operator from his cage, by means of a switch button at his hand or under his foot.

He does not stop the operation of his crane while he walks the runway with a pail of sand at the risk of his life. Nor does he risk the lives of his fellows by having them ride the end carriage to pour sand from a bucket in a wasteful manner.

He merely depresses the switch button, in his cab, to release sand, and he removes the pressure to close the valves and conserve the sand.

N-L for Safety!

▽ ▽ ▽ ▽

N-L UNIVERSAL SIGNAL LANTERNS perform just as definite a service in their field.

Being of cast aluminum construction they present at least two features of unusual importance. The first lies in the ability to withstand weather, acid atmospheres and rough handling. The second lies in the unusually light weight.

In fact, they combine the ruggedness of brass with the lightness of sheet metal, and do away with the necessity for easily rusted and battered frames with consequent short lives and frequent replacements.

These points, considered with the various designs procurable, have brought to N-L Universals a hearty welcome in the danger signal field.

▽ ▽ ▽ ▽

We are proud to sign ourselves as the makers of these SAFETY APPLIANCES.

N-L

THE NICHOLS-LINTERN CO.

7960 LORAIN AVENUE

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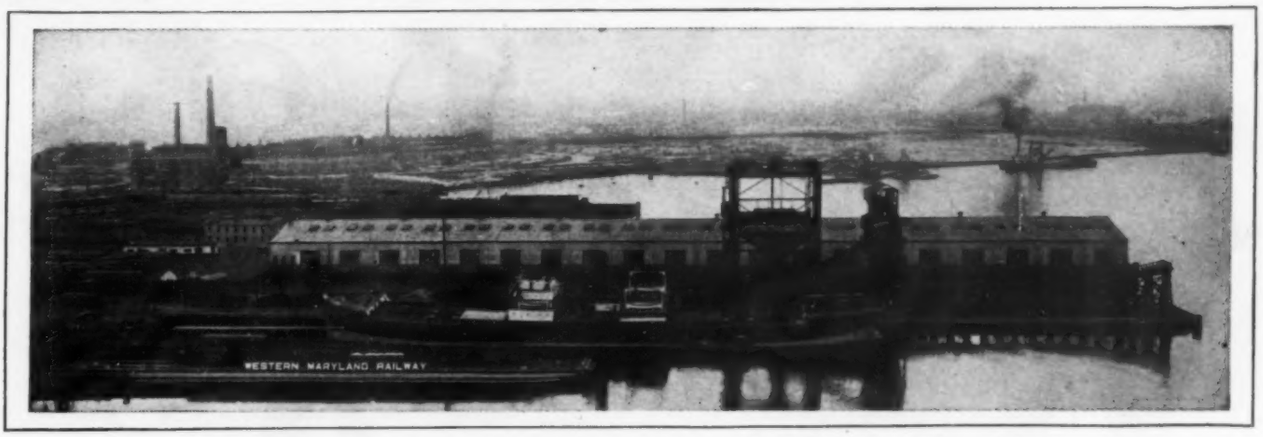
Detroit, Mich.



S.S. BEECHPARK *loading at Port Covington Pier of the Western Maryland Railway, Baltimore, Md.*

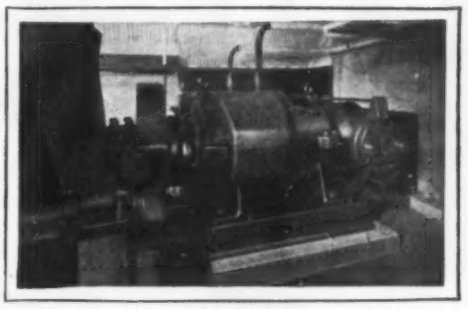
Where reliability is essential

FORTY coal cars, each of 100-ton capacity, can be dumped each hour at the Western Maryland Railway's new Port Covington Coal Pier, Baltimore. And at times this guaranteed capacity of the equipment must be reached within a fraction of a minute, that rails may be kept clear and steamers sail on time.

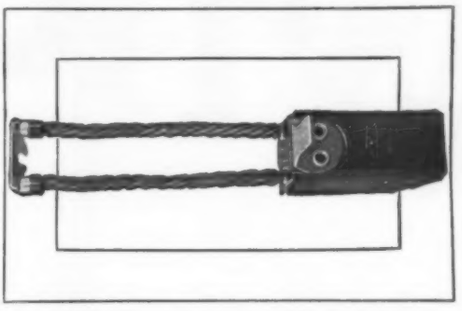
Here freight cars are lifted bodily and dumped as easily as you would a bucket. This giant mechanism must be able to leap to the peak of performance at a moment's notice. For the sake of the constant readiness and complete reliability that are so precious, every operation is electrically performed.

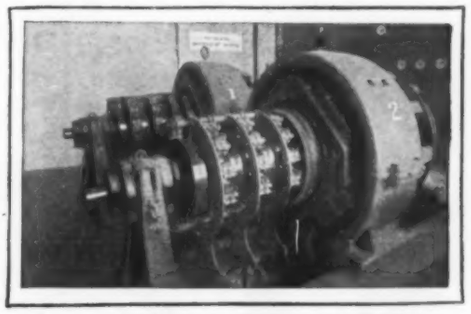
The electrical equipment on this pier is fitted throughout with National Pyramid Brushes, on hoists, elevators, even on "the mule." Clouds of coal dust may sweep the motors and converters; fog may roll in from the harbor; but these brushes recognize no master save electricity.

Our Sales Engineers are always at your service.



The mule that never bites, kicks or balks. It pushes heavy coal cars up a steep grade to be dumped.





A 750 KW, 250-volt rotary converter at Port Covington.

Manufactured and guaranteed by

NATIONAL CARBON COMPANY, INC., Cleveland, Ohio—San Francisco, Cal.

Canadian National Carbon Co., Limited, Toronto, Ontario

Emergency Service Plants

CHICAGO, ILL.
551 West Monroe St.
Phone: STAte 6092

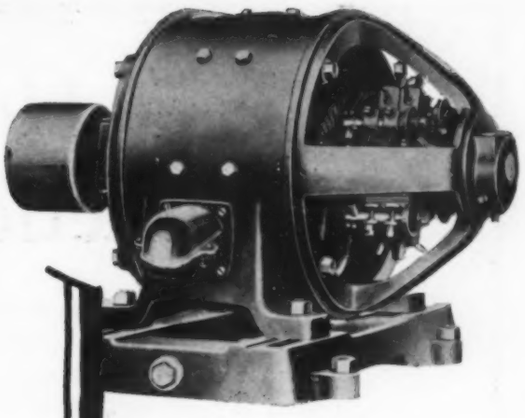
PITTSBURGH, PA.
7th Floor, Arrott Power Bldg. No. 3
Barker Place
Phone: SMIthfield 0740

NEW YORK, N. Y.
237 East 41st St.
Phone: VANderbilt 0425

Which? Where? When?

Western

OFFICES IN FORTY IN



Such questions as these can be readily answered when you rely on Western Electric for motors and control.

Which? Western Electric stocks of motors and control are large and varied.

Where? There is a Western Electric Distributing House near you, ready to meet your demands.

When? Immediate attention to your orders and the nearness of our House assure you prompt delivery.

To give this nation-wide service Western Electric has forty-nine Distributing Houses at strategic points throughout the country. At least one of the following is near you—Pittsburgh, Youngstown, Chicago, Cleveland, Buffalo and New York—stocked not only with motors and control, but with the countless electrical supply items you are constantly needing.

We suggest that you look now into the possibilities of Western Electric service for your business. For full information get in touch with our nearby House, or write to the Western Electric Company, 100 East 42nd Street, New York City.

Visit our booth at the
IRON AND STEEL EXPOSITION
Duquesne Garden, Pittsburgh, Pa.
Sept. 15th to 20th, 1924.

Speed Way

Drills

Made in different types for a wide variety of jobs. They are light, portable and sturdy.

When you want a drill that can do the work and do it quickly, Western Electric will supply you.

Electric

INE PRINCIPAL CITIES

How much is production worth to you?

NOBODY enjoys seeing overhead expense grow. And a fertile field for its growth is in the capital account, around the item of plant equipment. Cost estimates on new machinery often cause wry faces. But first cost in a machine is not the important consideration. Can it "pull its weight in the boat"?

Can it, in other words, *increase production* more than it increases overhead expense? If it can, the percentage of overhead in the unit cost of the product, and the unit cost itself, will actually *decrease*. The answer is in PRODUCTION.

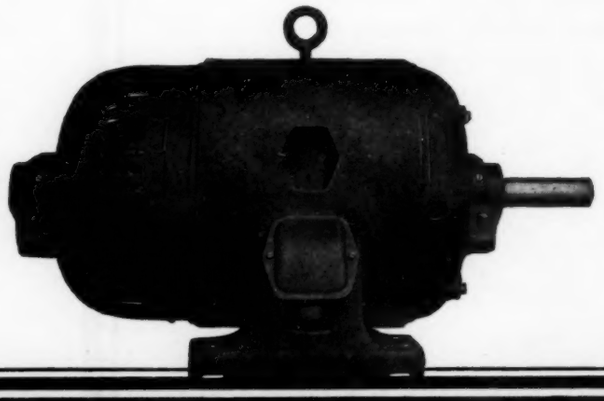
If you could increase production by 10 per cent, through a 5 per cent increase in overhead, with no increase in labor cost, you would do it, wouldn't you? There are plants today—perhaps yours is one of them—which can do better than that. Some of them can increase production from 15 to 30 per cent, for an increase of only 1 or 2 per cent in total overhead. How?

By substituting Fynn-Weichsel Motors for induction motors driving machines. The induction motor lags in speed; the Fynn-Weichsel Motor runs at constant, synchronous speed over a wide range of load.

The induction motor, by its poor power-factor, causes serious voltage drop in the lines, with poor regulation resulting in slowing down all machines as the voltage slumps.

The Fynn-Weichsel Motor brings your power-factor to unity, with resultant current saving and uniform voltage regulation.

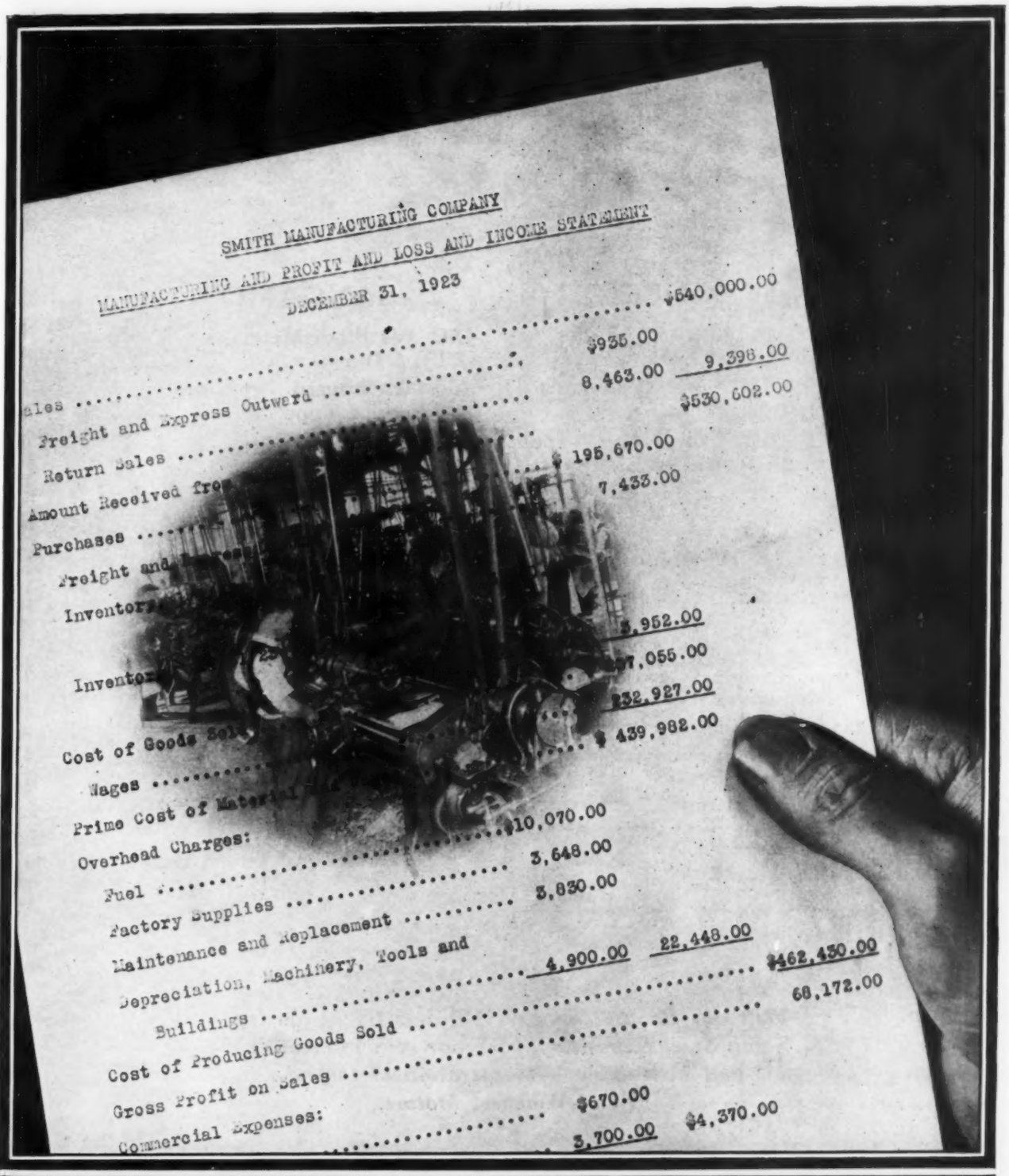
The resulting gain in operating efficiency and improved production, amply justify the investment.



Fynn-Weichsel

The motor that corrects power-factor

8410-16



WAGNER ELECTRIC CORPORATION

SAINT LOUIS

WAGNER ELECTRIC CORPORATION	NAME
You may send me—without obligation on my part—a copy of your bulletin No. 134, describing THE FYNN-WEICHSEL MOTOR.	COMPANY
	STREET
	CITY STATE

WAGNER

Polyphase Induction Motors
- Slip Ring Type
- Squirrel Cage Type

Single Phase Motors
- Repulsion-Induction Type
- Split Phase Type

Flynn-Weichsel Motors—Polyphase

Power Transformers

Distribution Transformers

ALSO

States Company Meter Testing Apparatus

Lind Aluminum Field Coils

Economy Street Railway Watthour Meters

Baker Transformer Temperature Signals

SANGAMO

D.C. Watthour Meters, Type D-5
- Switchboard Type
- Service Type

Portable Test Outfits

A.C. Watthour Meters, Type H
- Single Phase and Polyphase
- Switchboard Type
- Service Type

Maximum Demand Meters

Rotating Standards

Amperehour Meters
- Switchboard Type
- Locomotive Type
- Service Type

Current and Potential Transformers

MAY WE SERVE YOU?

Visit our Booths Numbers 110 and 119 at the Iron and Steel Exposition. See our very interesting and instructive demonstration of the new Fynn-Weichsel Motors.

LUDWIG HOMMEL & CO.

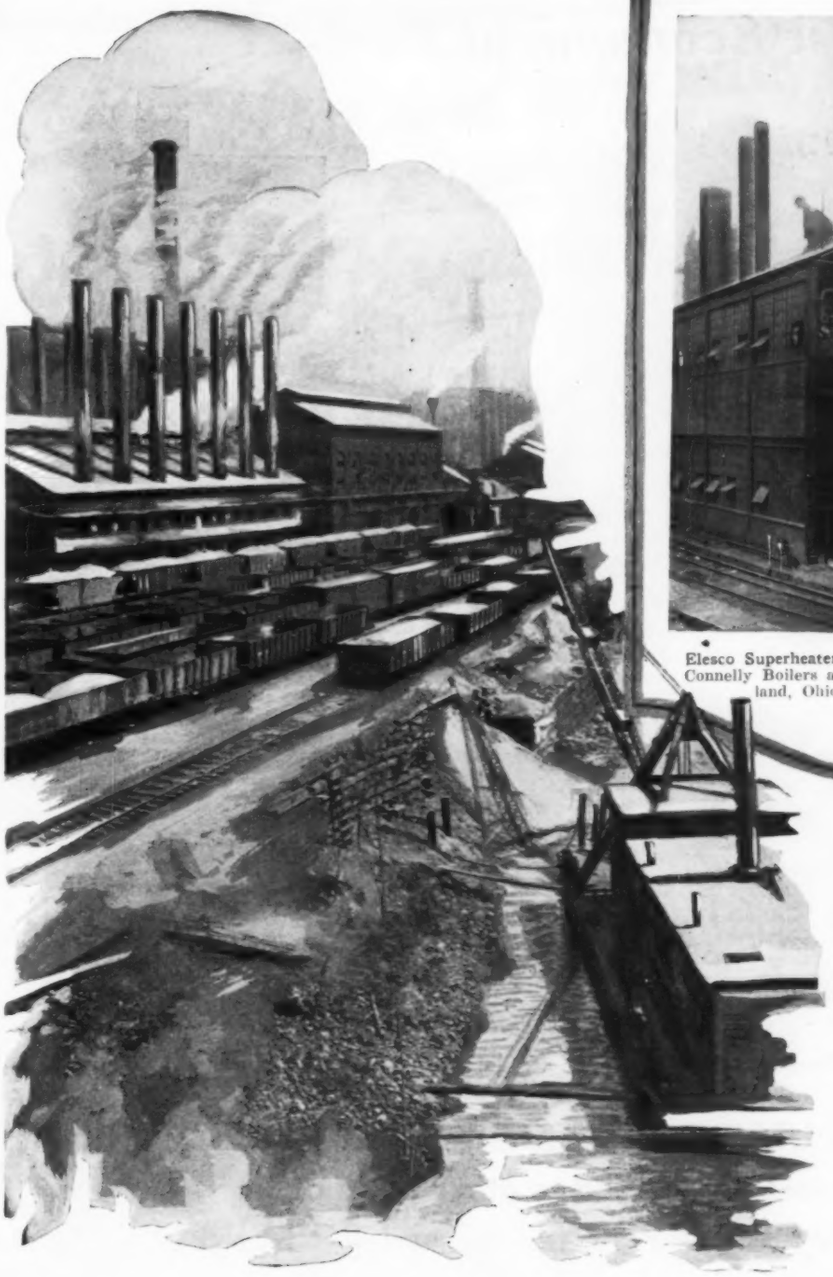
929 Penn Avenue
PITTSBURGH, PA.

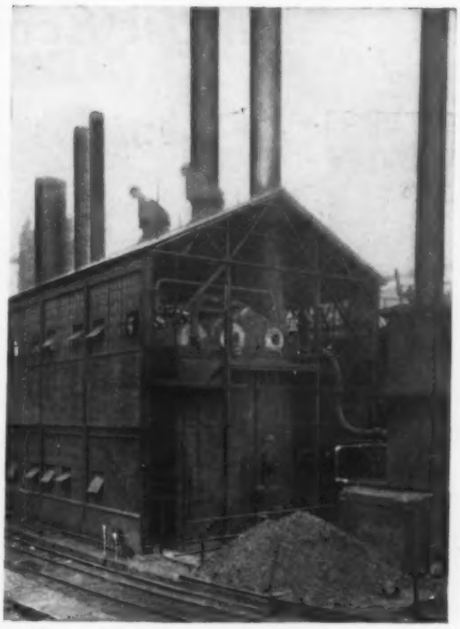
Rose Building
CLEVELAND, O.

Pittsburgh District Managers: Wagner Elec. Corporation
Sales Representatives Sangamo Elec. Co.

Dependable Waste and Direct Fired Superheaters

in the Iron and Steel Industry





Elesco Superheaters installed in three 4000 sq. ft. Connelly Boilers at The Bourne Fuller Co., Cleveland, Ohio, Superheat 100 degrees

ELESCO SUPERHEATERS

are well represented in the iron and steel industry. There are Elesco Waste Heat and direct fired installations in your vicinity. Why not visit these and let the men who operate them tell you of their advantages?

THE SUPERHEATER COMPANY

17 East 42nd Street NEW YORK — Peoples Gas Building CHICAGO

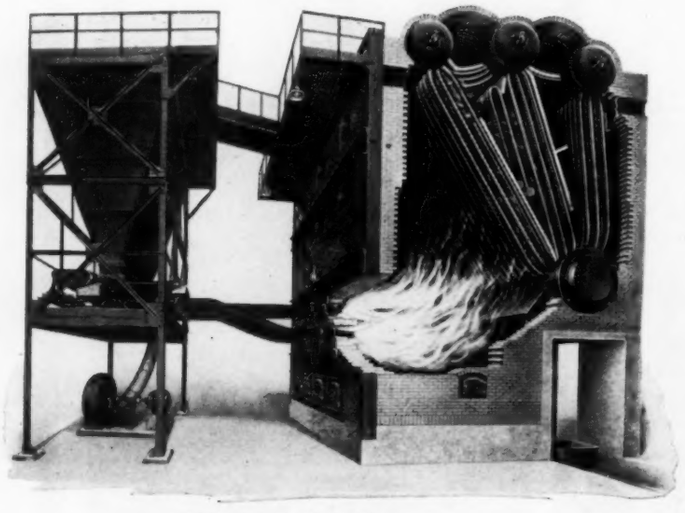
Philadelphia Boston Pittsburgh

Canada: The Superheater Co., Limited, Montreal

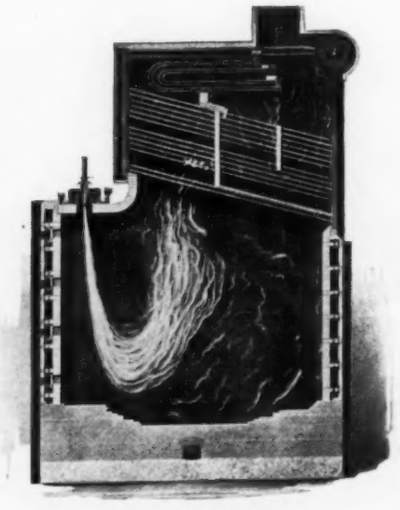
82,000,000 HORSEPOWER EQUIPPED IN LOCOMOTIVE, STATIONARY AND MARINE SERVICE

PULVERIZED COAL

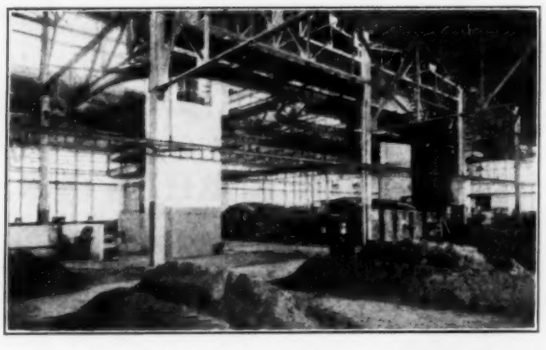
Most Economical Fuel



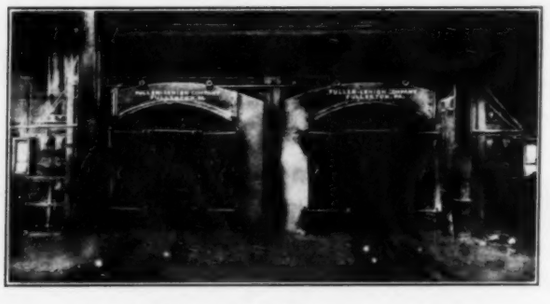
Horizontal Fired Boiler



Vertical Fired Boiler



Pulverized Coal Fired Melting Furnace



Pulverized Coal Fired Annealing Furnace

FULLER PULVERIZED COAL EQUIPMENT
is successfully applied to other types of
METALLURGICAL FURNACES and BOILERS

Consult our Engineers

FULLER-LEHIGH CO., Main Office and Works:
(FULLER ENGINEERING DIVISION) FULLERTON, PA.

New York, N. Y. 50 Church St.
London, Eng. 25 Victoria St. Westminster, S. W. I.
Germany, Hamburg "Wallhof" Glockengiesserwall 2
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Bilbao, Spain Rampas de Uribitarte, 1
Sydney, N. S. W. 191 Queen St.

Hayward Buckets

Dig and rehandle economically the Hayward Way

In steel mills, foundries, and other industrial plants, bulk material digging and rehandling can be quickly and efficiently accomplished by the Hayward line of "all-purpose" buckets. It consists of Clam Shell, Orange Peel, Clam Shell Electric Motor, Drag Scraper, and special types of buckets—for every type of operating machine.

Hayward Clam Shell Buckets, made in a variety of capacities, are particularly suitable for handling such bulk materials as coal, ashes, sand, ore, clay, lime, stone, coke, etc.

For certain classes of iron ore and slag digging, excavating and rehandling, Hayward Orange Peel Buckets prove highly satisfactory.

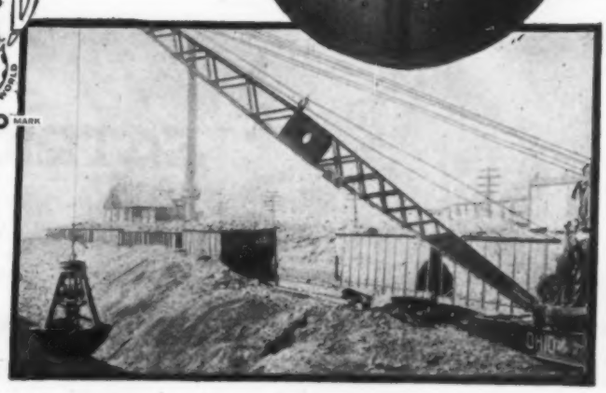
Hayward Electric Motor Buckets are easily and quickly attached or detached from any hoisting unit, making the unit available for other service. For instance, a skull cracker can be used for breaking up slag, and then a Hayward Electric Motor Bucket can be immediately attached to load the slag.

It will pay you to investigate. Catalogues, completely illustrating and describing the Hayward line, will gladly be sent on request.

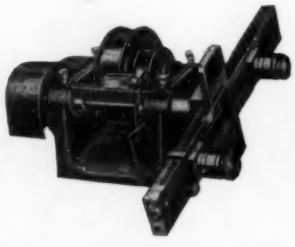
THE HAYWARD CO.

50 Church Street
NEW YORK, N. Y.

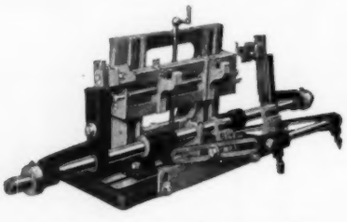
3025-Y



Peerless Pinion Puller—a portable hydraulic type designed for easy and rapid removal of pinions from armature shafts.

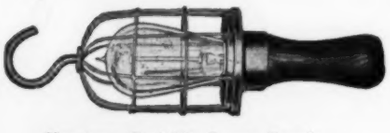


Segur Coil Winding Tools—illustration shows Hair-Pin Loop Armature Coil Winder in combination with special lathe head.



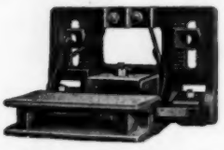
Segur Coil Winding Tools—illustration shows Coil Spreader, by use of which the coils are spread or pulled into proper shape.

Segur Coil Winding Tools—illustration shows Coil Taping Machine fitted with new self-feeding attachment.



Keystone Portable Lamp Guards—illustration shows Standard type which is typical of a broad line of exceptionally strong portable guards.

This material will be exhibited in Spaces 50-51 at Iron and Steel Exposition in Pittsburgh, Sept. 15-20.

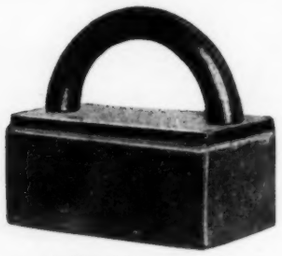


Keystone Contact Rail Material—showing one of many types of contact rail shoes.

KEYSTONE
ELECTRICAL SHOP
EQUIPMENT

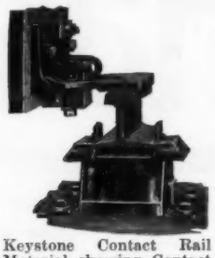
Read the list and check off your requirements. These items are just a few from the "Keystone" Line. Write for complete data.

- Segur Coil Winding Tools
- Peerless Armature Shop Tools
- Contact Rail Material
- Golden Glow Headlights
- Golden Flow Floodlights
- Keystone Turbo-generators
- Keystone Headlight Switches
- Keystone Gauge Lights
- Keystone Terminal Blocks
- Golden Glow Round-house Lighting Fixtures
- Keystone Portable Lamp Guards
- Keystone Tender Rearlights
- Locomotive Wiring Connectors
- Keystone and Garton-Daniels Lightning Arresters
- Rail Bonds
- Aetna Smoothing Stones



Aetna Commutator Smoothing Stones

Aetna Commutator Smoothing Stones — for smoothing commutators, will outwear any other smoothing stone.



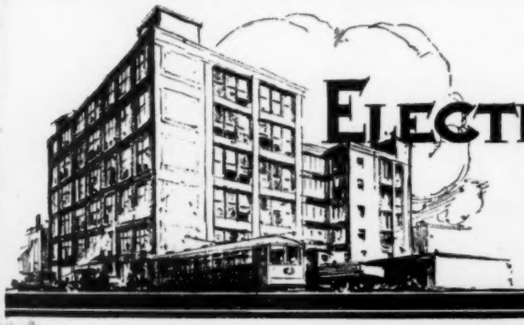
Keystone Contact Rail Material showing Contact Rail Shoe Assembly for Over-Running Contact.

Keystone Contact Rail Material—illustration shows typical Contact Rail Shoe Assembly for Under-Running Contact.

Keystone Contact Rail Material—showing typical rail standard assembly. Standards are made for supporting one or more rails.

Keystone Universal Collectors—illustration shows Trolley Wire Wheel Type and is but one of many designs cataloged.

Keystone Universal Collectors—showing Wheel Pantagraph type—many other designs cataloged.



ELECTRIC SERVICE SUPPLIES CO.

PHILADELPHIA 17th and Cambria Sts.
NEW YORK 50 Church St.
CHICAGO Monadnock Bldg.
PITTSBURGH 829 Oliver Building
SCRANTON 316 N. Washington Ave.
BOSTON 88 Broad St.
Lyman Tube & Supply Co., Ltd., Montreal, Toronto, Winnipeg, Vancouver

R. & I. E. EQUIPMENT FOR OUT DOOR SERVICE

"Interchangeable all Along the Line"

All R. & I. E. Equipment, whether it be a simple bus support or complete substation combination, is absolutely standardized and interchangeable.

Think what this means to you in decreased installation costs—in simplified maintenance and stock keeping.

Our new bulletins describe all the many convenient and practical features of R. & I. E. Equipment—these should be in your files for ready reference.

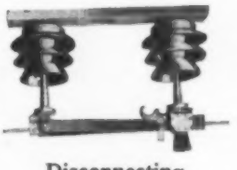
At the Iron and Steel Exposition Duquesne Garden, Pittsburgh, Sept. 15-20 this Company will exhibit in Booth 98.

Drop in to see us

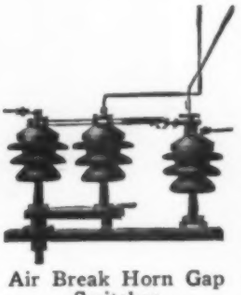
RAILWAY AND INDUSTRIAL ENGINEERING COMPANY
GREENSBURG, PA.
TRANSMISSION SWITCHING AND PROTECTIVE EQUIPMENT
DISTRICT OFFICES: PITTSBURGH NEW YORK BOSTON CHICAGO CINCINNATI

Insulator Units

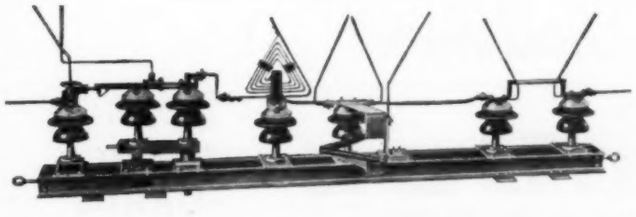
Bus Supports



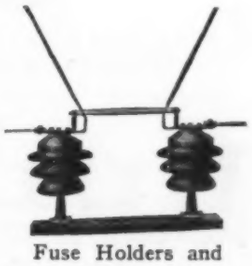
Disconnecting Switches



Air Break Horn Gap Switches



Single Pole Unit, Combination Horn Gap Switch, Lightning Arrester and Horn Gap Fuse



Fuse Holders and Fuses

Cylindrical Choke Coils

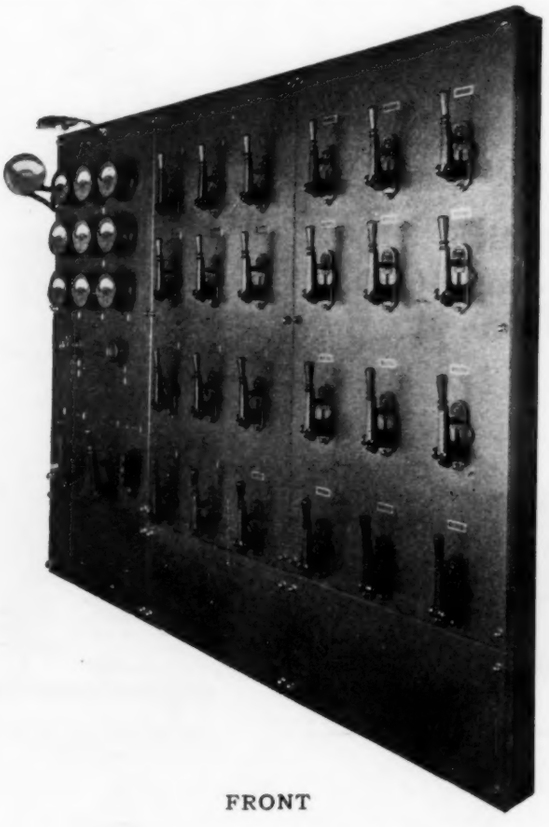
"BULL DOG" Super-Safety Switchboards for Steel Mills

The simplicity of design and ruggedness of construction of "BULL DOG" Super-Safety Dead Front Industrial Switchboards will surely appeal to you.

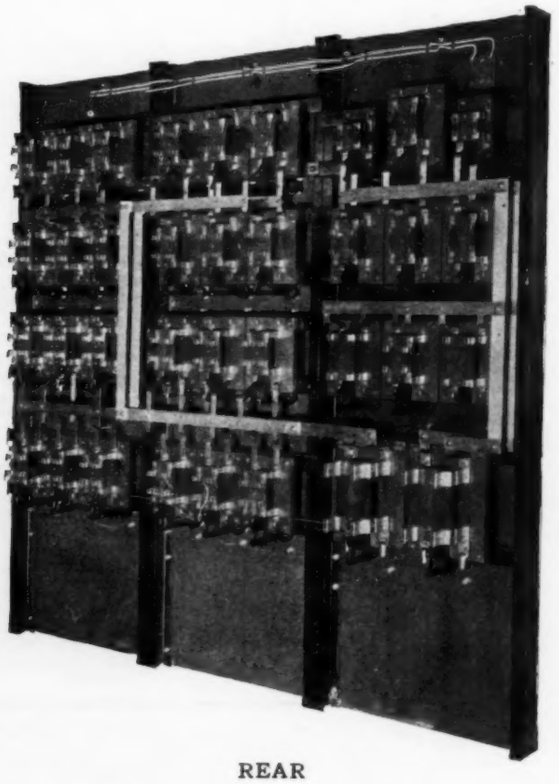
Here are some of the features incorporated:

1. No copper in the Switches is less than 100-amp. capacity for mechanical strength.
2. Switches are double break type.
3. Switches may be locked in either the open or closed position.
4. Individual switch units may be replaced with larger units and the busbars reinforced to take care of these additions.
5. A wiring space is provided between the Switches and the rear of front panels of the Board, making a neat, compact and accessible arrangement.
6. Each Panel or section of these Switchboards is shipped as a complete unit. No reassembly of Switches and busbars is necessary (except to connect sections together) when the Switchboard reaches the job.

After the Switchboard is installed, a wire grill or sheet steel enclosure will serve to keep unauthorized persons from the rear of the Board, where the live parts are mounted and further enhance the Safety and Efficiency of the installation.



FRONT



REAR

Write for a copy of Bulletin No. 25

SAFETY SWITCHES

BULL DOG

MUTUAL ELECTRIC & MACHINE CO.

DETROIT MICH. U.S.A.

PANEL BOARDS

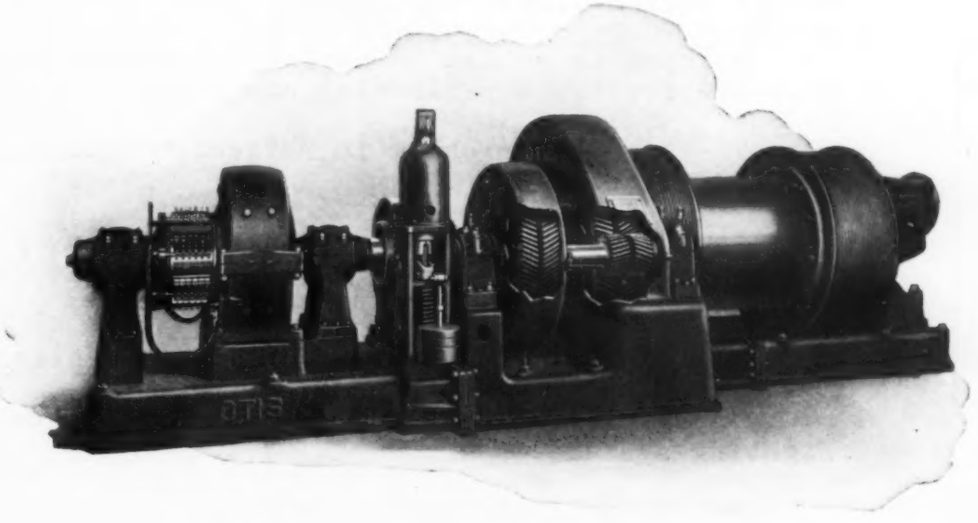
Automatic

BLAST FURNACE HOISTS

and

BELL HOISTS

Special Hoisting Equipment for Steel Plants



OTIS ELEVATOR COMPANY

Chamber of Commerce Building, Pittsburgh

Booths 29-30-31, Iron and Steel Exposition
Duquesne Garden, Pittsburgh, Sept. 15 - 20.

ALLISON J. THOMPSON
President

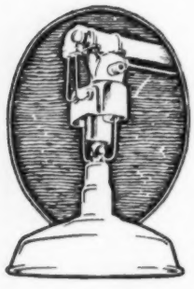
Dirty Reflectors do not reflect and wear out more quickly.

THOMPSON
Safety LOWERING Switch
—or Disconnecting Hanger

Manufactured by
The Thompson Electric Co.
226 St. Clair Avenue N. E.
Cleveland, Ohio, U. S. A.

Enables High Lamps to be lowered away from the electric circuit for Cleaning and Renewals

As necessary to the reflector as the reflector is necessary to the bulb.



REFLECTORS OR SHADES?

One is constructive – saving the upward portion of the light by bending it downward into the working area.

The other is obstructive – merely preventing the upward light from going 'anywhere'.

A dirty reflector makes a first class Shade – but it does not save any light.

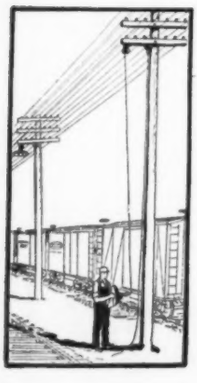
Nothing is gained by buying reflectors unless they are kept in a reflecting condition.

The greatest problem in reflector-cleaning is 'how to get at it'.

The Thompson Safety Lowering Switch or Disconnecting Hanger helps to solve this problem by making reflector-cleaning easy and safe.

No climbing hazards – no electrical hazards.

Inexpensive and easily included in present lighting systems.



Get Catalogue B-22 for details.

Very truly yours,

THE THOMPSON ELECTRIC CO.

A. J. Thompson

Only When Bulbs and Reflectors Are Kept Clean and Sparkling Are They Worth the Money Paid for Them

Something New!

A new C-H Controller of unusual interest to iron and steel electrical engineers—will be exhibited (for the first time) in actual operation in the Cutler-Hammer Booth at the *Iron and Steel Exposition*, Duquesne Garden, Pittsburgh, September 15th to 20th.

The remarkable operating characteristics as proven during nearly a year of service in one steel plant—stamp this controller as another important step in engineering development.

If you are unable to attend—write for a copy of Publication No. C-2.

THE CUTLER-HAMMER MFG. CO.
Motor Control Department

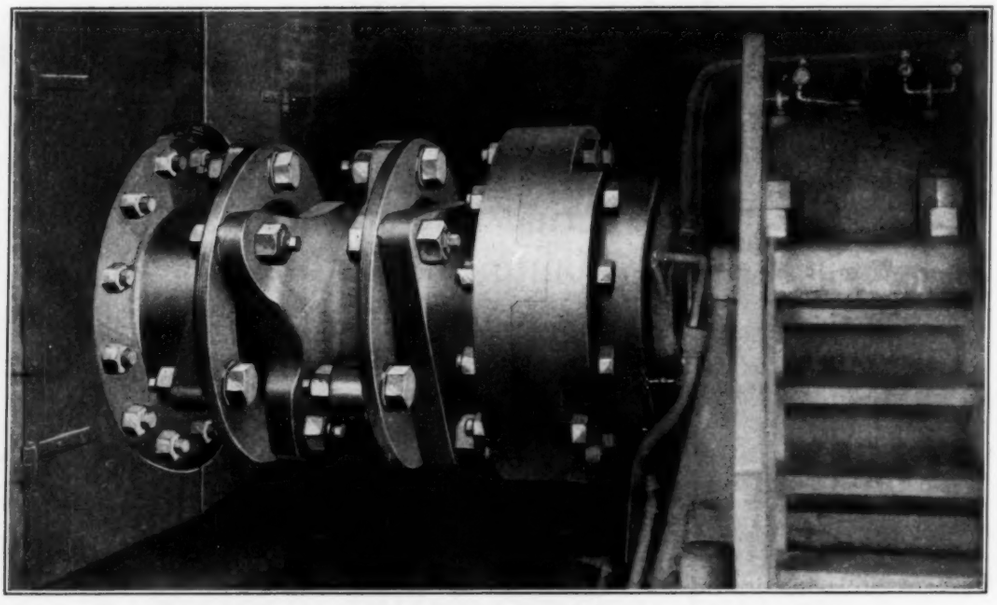
NEW YORK	CHICAGO	PITTSBURGH
PHILADELPHIA	CLEVELAND	BOSTON
CINCINNATI	DETROIT	ST. LOUIS
BUFFALO	WILKES-BARRE	NEW HAVEN

Works: **MILWAUKEE** *and* **NEW YORK**
Northern Electric Co., Ltd., Canada

CUTLER-HAMMER

THOMAS FLEXIBLE COUPLINGS

FOR MAIN ROLL DRIVES



Thomas Mill Type Coupling on 84″ Plate Mill, 2500 H.P., 235 R.P.M.
Youngstown Sheet & Tube Company

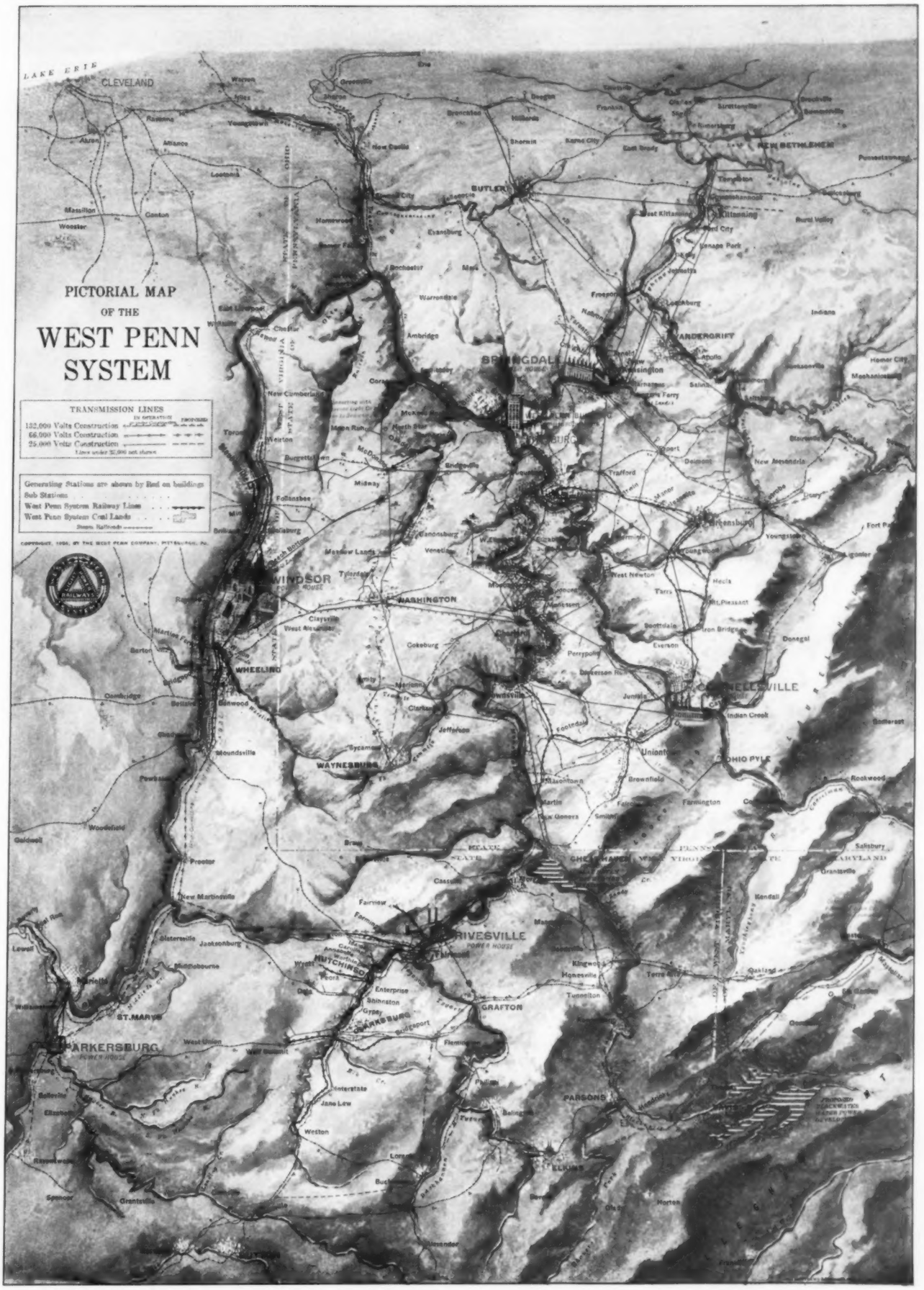
Above coupling and another on the 5,000 H.P. 197 R.P.M. 132″ plate mill drive at this same plant have operated a total of six years with absolutely no maintenance charge.

No sliding or wearing parts
No loosely connected members
No frictional resistance to end float
No lubrication
Three very accessible bolts, removal of which frees either end of drive

The Thomas coupling is the only mill spindle which has these features. The first two are the most important, as a "tight" drive eliminates all backlash and prevents the hammering action, which is so destructive to gears, bearings and shafts. The net result is an immediate reduction in maintenance costs.

Thomas Flexible Coupling Co., Warren, Pa.

SALES OFFICES: Pittsburgh Chicago Cleveland Philadelphia Boston St. Louis New York Springfield


PICTORIAL MAP
OF THE
WEST PENN
SYSTEM
TRANSMISSION LINES
IN OPERATION
PROPOSED
132,000 Volts Construction
66,000 Volts Construction
25,000 Volts Construction
Lines under 25,000 not shown
Generating Stations are shown by Red on buildings
Sub Stations
West Penn System Railway Lines
West Penn System Coal Lands
Steam Railroads
COPYRIGHT, 1924, BY THE WEST PENN COMPANY, PITTSBURGH, PA.
LAKE ERIE
CLEVELAND
OHIO
PENNSYLVANIA
WEST VIRGINIA
MARYLAND
BUTLER
SPRINGDALE
WINDSOR
WASHINGTON
WHEELING
WAYNESBURG
GRAFTON
PARKERSBURG
PARSONS
ELKINS
NEW BETHLEHEM
KITTANNING
INDIANA
MONONGAHELA
UNIONTOWN
OHIO PYLE
CONNELLSVILLE
GREENSBURG
NEW KENSINGTON
ARNOLD
ARDERORIFT
MOUNDSVILLE
NEW MARTINSVILLE
ST. MARYS
JANE LEW
WESTON
SPENCER
GRANTSVILLE

HYATT ROLLER BEARINGS FOR ELECTRIC MOTORS

Fewer Repair Jobs

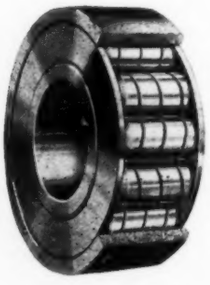
HOW many motors, month in and month out, pass through your electrical shop for repairs?

Wouldn't you like to cut the number in half?

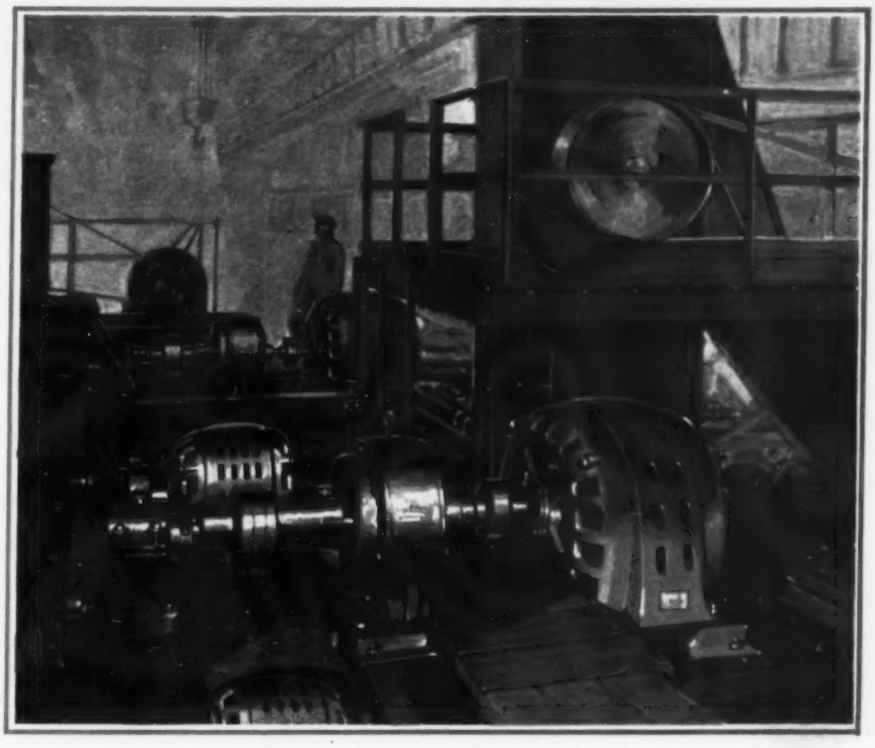
If you could cut out all repairs due to oil soaked insulation your electrical repair work would shrink to less than half its size, wouldn't it?

Hyatt bearings in your motors will eliminate leakage of oil and grease into field and armature windings.

Full information furnished on request, without obligation.



HYATT ROLLER BEARING COMPANY
NEWARK, NEW JERSEY



50 motor-years of 23-hour service for every bearing replacement

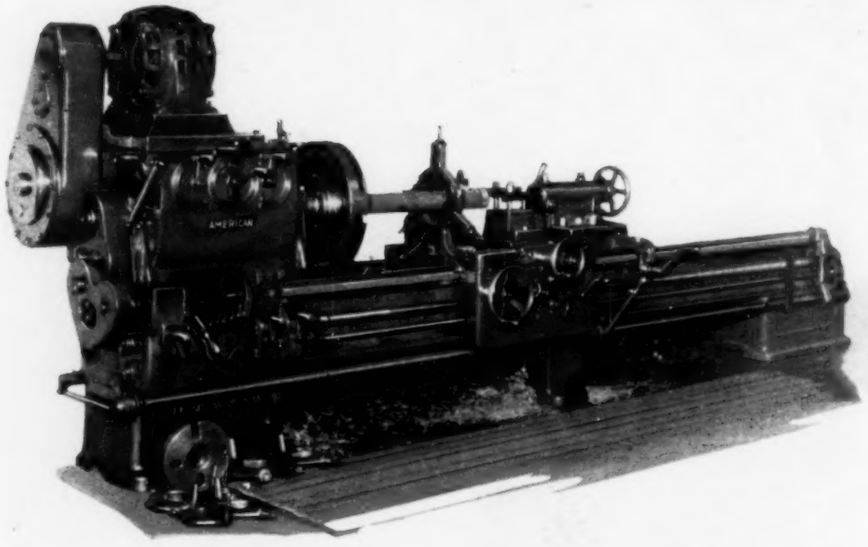
READ THE STORY AS TOLD BY A USER:

"We have been using Fairbanks-Morse Ball Bearing Motors for about seven years and find them very satisfactory. They are built rugged and strong and will stand lots of abuse.

"Out of a group of fifty ball-bearing motors running twenty-three hours per day for about five years, we have renewed only five bearings . . . . . and it only takes an hour to put in a new bearing."

It's worth while to learn more about Fairbanks-Morse Ball Bearing Motors and how they are saving money for others. Let us tell you.

FAIRBANKS-MORSE
ball bearing motors



Every Fairbanks-Morse Motor has a rigid cast frame with broad, solid feet

When you put a motor on a job with gear or chain drive *where it has to pull hard,* as on a lathe speeded for production, you want one with a sturdy, rigid frame that will keep the gears properly meshed or the chain sprockets properly lined up. Broken teeth, stripped gears, and worn chains result from yielding motor frames or fastenings. If you choose a Fairbanks-Morse Motor you know the gears or sprockets will stay put and *the tool will go through the work* no matter how tough the metal or how deep the cut. If it is a Fairbanks-Morse Ball Bearing Motor, you know when it comes it is ready to run for a year; and twenty minutes for re-greasing each year is the only attention the bearings require.

Write into your specifications for machine tool motors:

1 Rigid cast frames with broad solid feet cast integrally with the frame.
2 Ball bearing with drain and refill plugs for lubricant so that the bearings can be re-greased without removing pinion, pulley or coupling.

Specify Fairbanks-Morse by name if you want to be sure of the best.

Specify Industry in which you are interested

☐ Automotive	☐ Metal Working
☐ Food Products	☐ Paper
☐ Grain and Milling	☐ Pumping and Irrigation
☐ Laundry	☐ Railway
☐ Lumber	☐ Textile
☐ General Use	☐ Wood Working

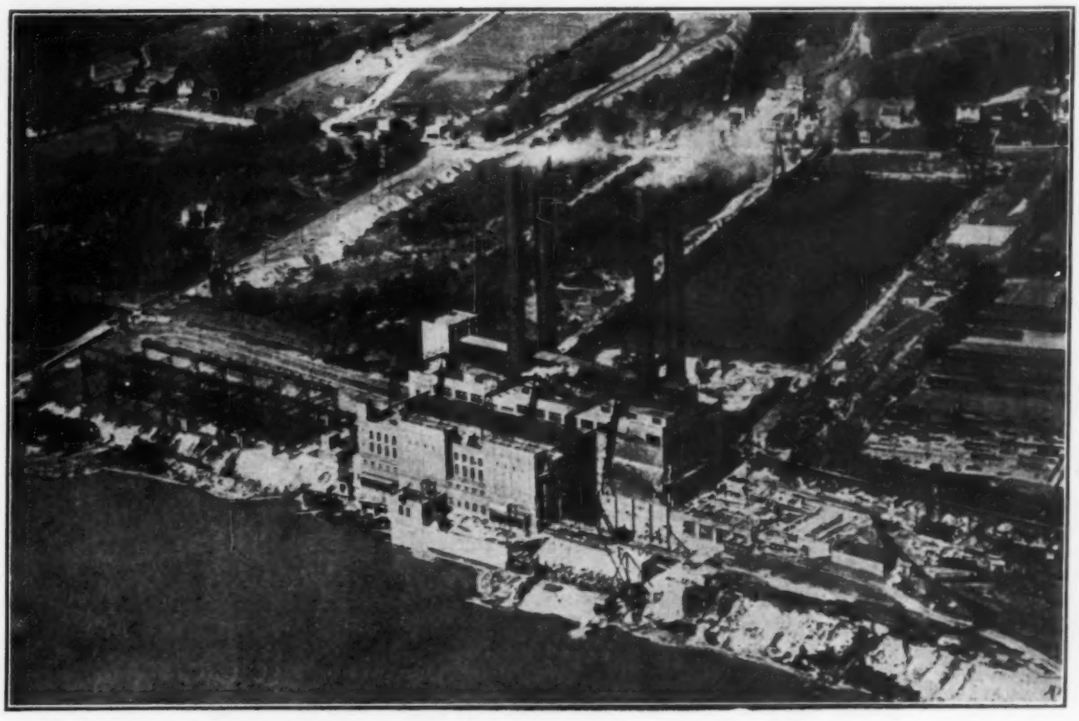
Write for Bulletins to Fairbanks, Morse & Co.
Indianapolis Works, Indianapolis, Indiana

FAIRBANKS, MORSE & COMPANY

Manufacturers Chicago, Illinois

25 branches throughout the United States at your service

A 724



To you, sir:—

This is merely by way of being an invitation to visit the great Colfax super power plant of the Duquesne Light Company while attending the Iron and Steel Convention.

Details may be had at our booth at the Exhibit.

DUQUESNE LIGHT COMPANY
PITTSBURGH, PA.

"Live in and Expand Your Business in Greater Pittsburgh"

"LE CARBONE" CARBON BRUSHES

Standard of Quality and Uniformity

They are supplied not alone to suit type of machine, but your operating conditions.

Guaranteed Without Argument.

Real Engineering Service.

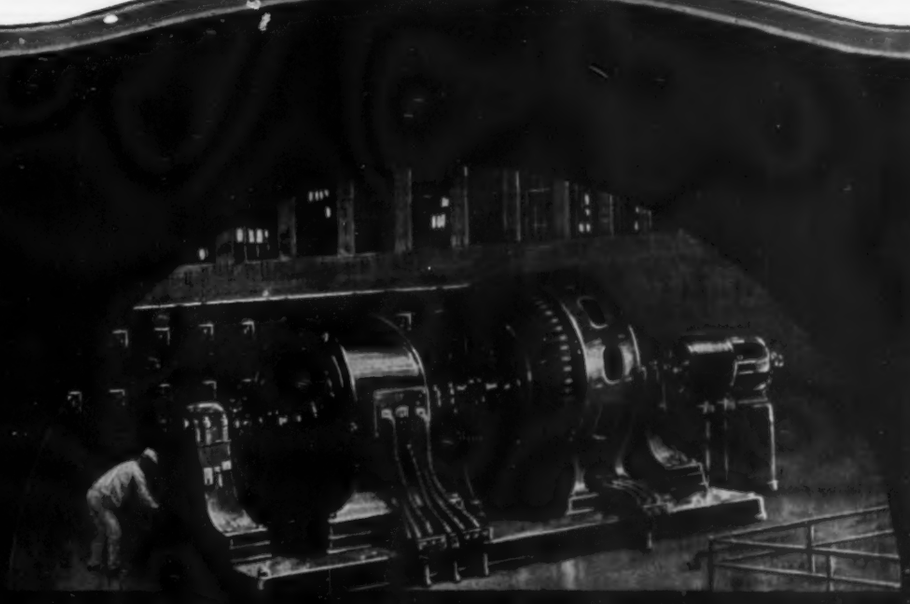
W. J. Jeandron, 345 Madison Ave., New York

Pittsburgh Office, 634 Wabash Bldg.
W. P. POYNTON, Electrical Engineer

San Francisco Office, 525 Market St.
W. R. CATCHING, Sales Engineer

Chicago Office, 1657 Monadnock Block
A. M. RAMSEY, Sales Engineer

Canadian Distributors:. Lyman Tube & Supply Co., Ltd.
Montreal and Toronto



ECONOMY *renewable* FUSES

INDUSTRIES using electrical energy save 80% annually in fuse maintenance costs when they install Economy renewable Fuses in the place of "one-time" fuse-equipment.

Economy Fuse performance is a matter of record—they were the first fuses using inexpensive bare renewal links for restoring blown fuses to their original efficiency to be *Approved in All Capacities* by the Underwriters' Laboratories.

Economy "Drop-Out" Renewal Links cost but little and make the restoration of a blown fuse the work of a moment only.

Your plant needs Economy Fuses. Investigate the quality of the electrical protection you now have from the standpoint of dependability, efficiency and economy.

Then order Economy Fuses installed.

For Sale by all leading Electrical Jobbers and Dealers.

ECONOMY FUSE & MFG. CO., Chicago, U. S. A.

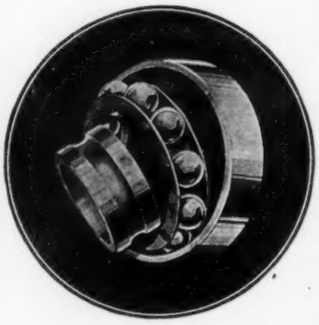
Economy Fuses are also made in Canada at Montreal

PRECISION BEARINGS

Make Good Machines Better

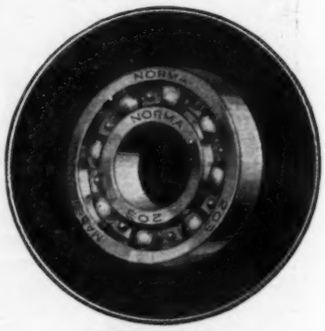
They strengthen what are often the weak parts in the structure—the shaft and spindle bearings. They minimize a prolific cause of trouble—friction and wear in the bearings. They reduce power consumption and oil consumption. They contribute materially to longer life, better performance, lower upkeep, increased and improved production.

"NORMA" PRECISION BALL BEARINGS



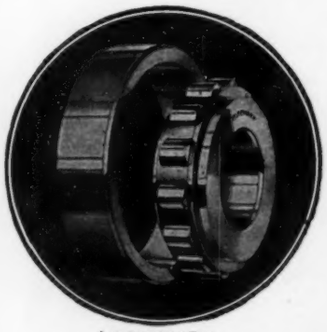
OPEN TYPE

Experience has proved the preeminent superiority of these high precision units under conditions where maximum serviceability and freedom from vibration under high-speed operation are essential. They have all the load-carrying capacity of any ball bearing, combined with a speed-ability which no other ball bearings have. For years past, they have been the standard bearings in tens of thousands of high-speed machines operating under severe conditions. They are increasingly in demand for high-speed grinders and drills, precision measuring devices, electric tools, fractional hp. motors and small generators.



CLOSED TYPE

HOFFMANN PRECISION ROLLER BEARINGS



STANDARD

Designed for conditions involving heavy loads, hard service, shock, jar and vibration, these high-precision, heavy-duty units have proved their entire success. They have all the speed-ability of the best ball bearings, with a much greater steady load-carrying capacity than any ball bearing and with a temporary overload capacity, as under shocks or in starting, which no ball bearing has. They are made in both standard and self-aligning types—some of the latter being wholly enclosed, lubricant packed and dust-and-moisture-proof. They are the preeminent bearings for high-duty, heavy-duty machines from which the utmost is demanded.

ENCLOSED SELF-ALIGNING

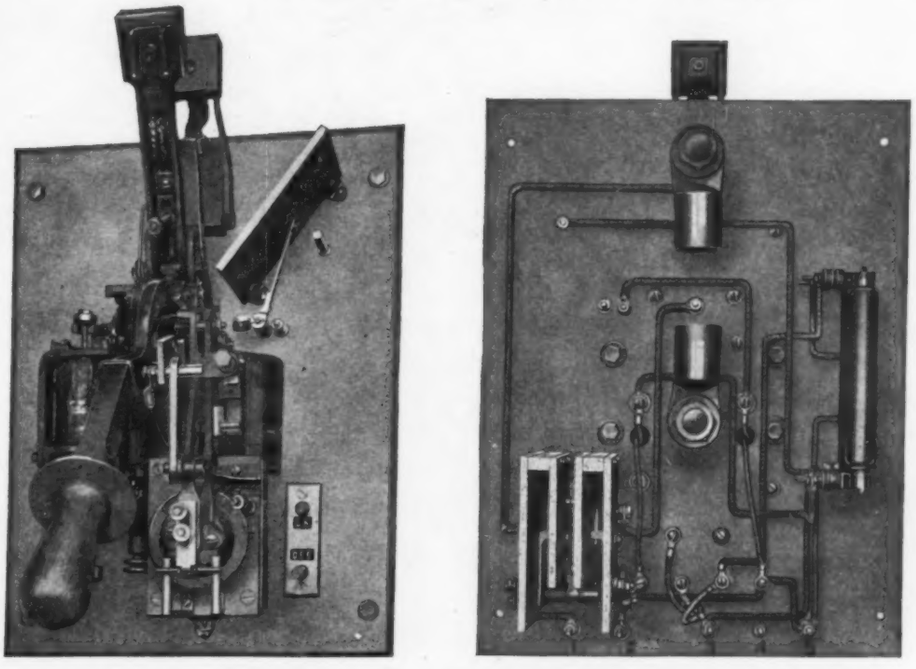
"NORMA" engineers will welcome an opportunity to work with yours in applying these high-precision bearings to the machines you make or use.

THE NORMA COMPANY OF AMERICA

Anable Avenue Long Island City New York

BALL, ROLLER AND THRUST BEARINGS

A Manually Operated Circuit Breaker
That Recloses Automatically



Front and Rear Views, Type "AHM" 600-Ampere Automatic Reclosing Circuit Breaker
With Removable Handle for Manual Operation

or

An Automatic Reclosing Circuit Breaker
That May Be Operated Manually

either way

This Circuit Breaker Embodies All That Is to Be Had in a Circuit Breaker
and Assures You High Grade Circuit Breaker Protection
At All Times and Under All Conditions

With That Refinement in Service That Can Be Had Only With

The Circuit Breaker with Brains

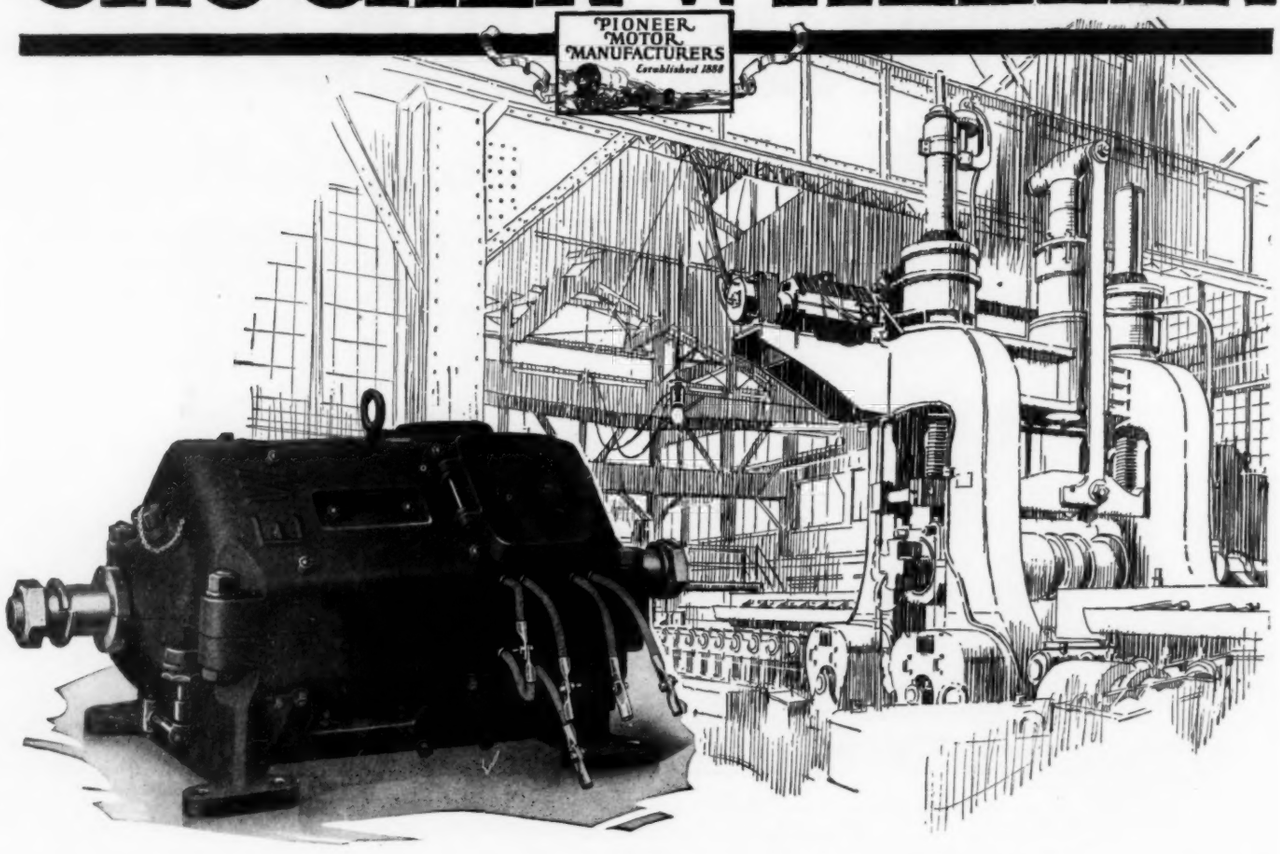
Bulletin 314-F Gives Details.

THE AUTOMATIC RECLOSING CIRCUIT BREAKER CO.

COLUMBUS, OHIO

PITTSBURGH: 1815 Oliver Bldg.
ST. LOUIS: 401 National Bank of Commerce Bldg.
WILKES-BARRE, PA.: 816 Miners Bank Bldg.
CHARLESTON, W. VA.: 317-318 Moore Bldg.

CROCKER-WHEELER



An Important Role in a Great Industrial Achievement

Crocker-Wheeler Motors and Generators are built in a wide variety of types for meeting the special requirements of every industry.

The greatest producer of iron and steel in the world—America!

Many are the noteworthy developments which have contributed to her stupendous achievement. Among them—electric motor drive.

In zealously promoting the adoption of electric motor drive in the iron and steel industry, the Crocker-Wheeler Company once more blazed a new trail. In 1894 this pioneer motor manufacturer developed and installed the first real system of motor control in a steel mill. Later on, it developed and installed the first successful reversing rolling mill motors. Both developments demonstrated to steel mills in general the advantages of electric motor drive—leading, eventually, to the general adoption of this form of drive throughout the iron and steel industry.

For 36 years Crocker-Wheeler *Quality* has been closely associated with outstanding accomplishments in all lines of industry.

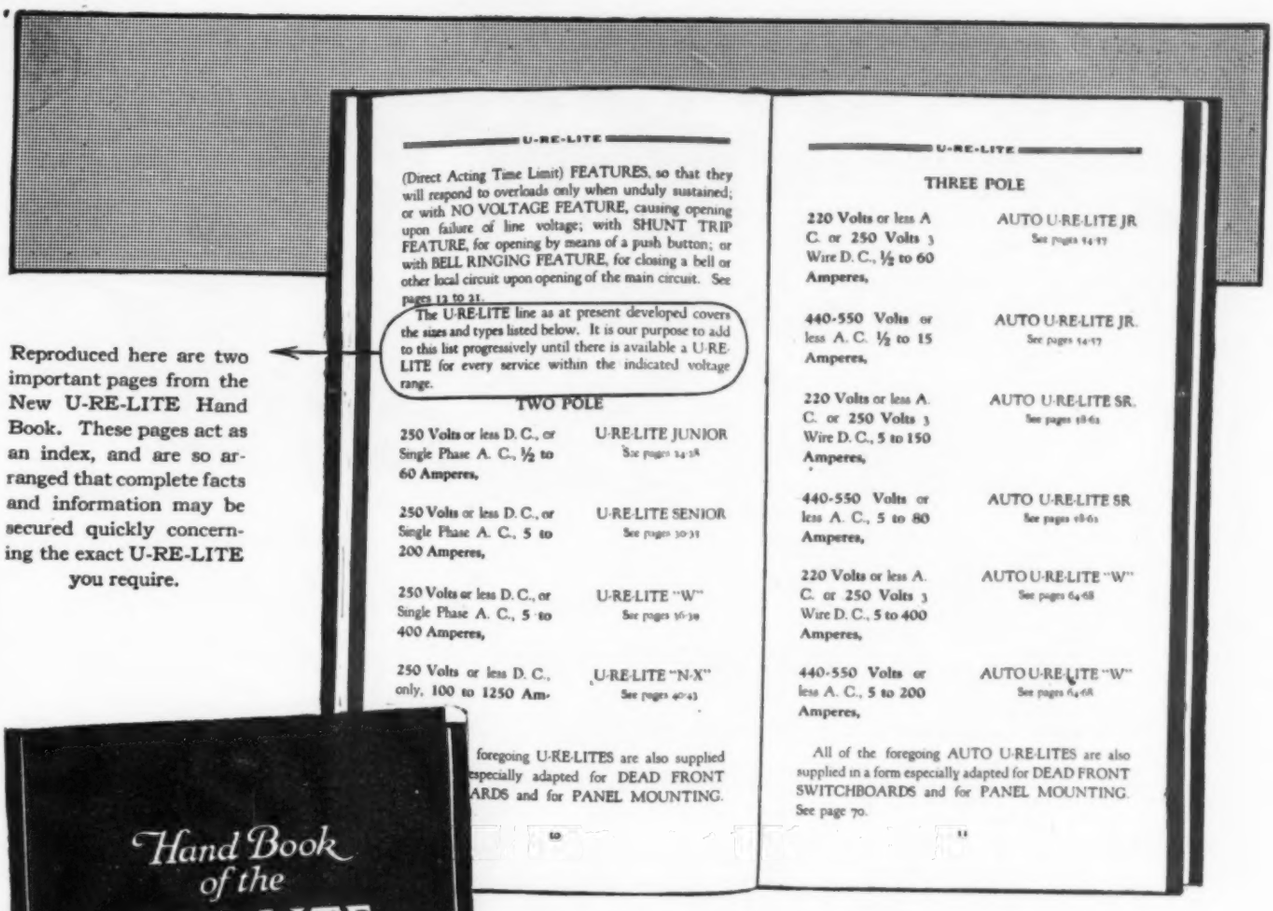
CROCKER-WHEELER COMPANY
TRADE MARK

CROCKER-WHEELER COMPANY, AMPERE, N. J.

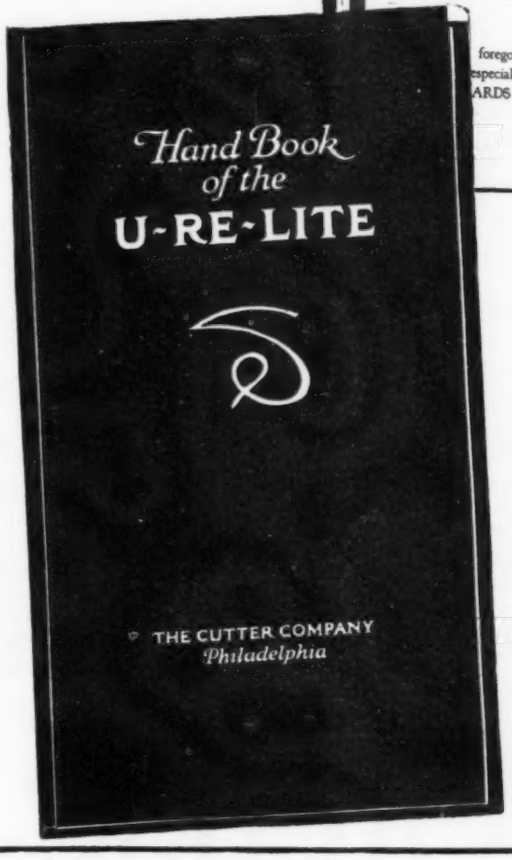
BALTIMORE	BUFFALO	DETROIT	PHILADELPHIA
BIRMINGHAM	CHICAGO	NEW HAVEN	PITTSBURGH
BOSTON	CLEVELAND	NEW YORK	SAN FRANCISCO

Foreign Distributor: International Western Electric Co.

MOTORS & GENERATORS


U-RE-LITE
(Direct Acting Time Limit) FEATURES, so that they will respond to overloads only when unduly sustained; or with NO VOLTAGE FEATURE, causing opening upon failure of line voltage; with SHUNT TRIP FEATURE, for opening by means of a push button; or with BELL RINGING FEATURE, for closing a bell or other local circuit upon opening of the main circuit. See pages 13 to 21.
The U-RE-LITE line as at present developed covers the sizes and types listed below. It is our purpose to add to this list progressively until there is available a U-RE-LITE for every service within the indicated voltage range.
TWO POLE
250 Volts or less D. C., or Single Phase A. C., ½ to 60 Amperes, U-RE-LITE JUNIOR See pages 24-28
250 Volts or less D. C., or Single Phase A. C., 5 to 200 Amperes, U-RE-LITE SENIOR See pages 30-31
250 Volts or less D. C., or Single Phase A. C., 5 to 400 Amperes, U-RE-LITE "W" See pages 36-39
250 Volts or less D. C., only, 100 to 1250 Am- U-RE-LITE "N-X" See pages 40-43
foregoing U-RE-LITES are also supplied especially adapted for DEAD FRONT ARDS and for PANEL MOUNTING.
10
U-RE-LITE
THREE POLE
220 Volts or less A C. or 250 Volts 3 Wire D. C., ½ to 60 Amperes, AUTO U-RE-LITE JR See pages 14-17
440-550 Volts or less A. C. ½ to 15 Amperes, AUTO U-RE-LITE JR. See pages 14-17
220 Volts or less A. C. or 250 Volts 3 Wire D. C., 5 to 150 Amperes, AUTO U-RE-LITE SR. See pages 58-61
440-550 Volts or less A. C., 5 to 80 Amperes, AUTO U-RE-LITE SR See pages 58-61
220 Volts or less A. C. or 250 Volts 3 Wire D. C., 5 to 400 Amperes, AUTO U-RE-LITE "W" See pages 64-68
440-550 Volts or less A. C., 5 to 200 Amperes, AUTO U-RE-LITE "W" See pages 64-68
All of the foregoing AUTO U-RE-LITES are also supplied in a form especially adapted for DEAD FRONT SWITCHBOARDS and for PANEL MOUNTING. See page 70.
11

Reproduced here are two important pages from the New U-RE-LITE Hand Book. These pages act as an index, and are so arranged that complete facts and information may be secured quickly concerning the exact U-RE-LITE you require.



The U-RE-LITE is primarily an appliance for the protection from overloading electric motors and power or lighting circuits. It does this by automatically opening the circuit in the event of excessive current flow. It is, in a word, an electric safety valve. It does what fused switches are intended to do, but accomplishes this end without attendant expense. When the U-RE-LITE is opened by an overload, it does not require the insertion of renewal parts, but by a twist of the wrist may be instantly reset.

SEND FOR THIS UNUSUAL BOOK—
IT WILL BE SENT FREE

The New Hand Book of the complete U-RE-LITE line is just off the press. Contains valuable and useful data, facts and figures on the various sizes and types of the famous U-RE-LITE. Bound in boards; size 5x9¼ inches; 96 pages; illustrating the U-RE-LITE, and half-tone pictures of installations, also detailed outline drawings.

THE CUTTER COMPANY
Philadelphia

The CUTTER COMPANY
ESTABLISHED 1888 PHILADELPHIA
1819 HAMILTON STREET

U-RE-LITE, JR.

KEYSTONE ACCOMPLISHMENTS

No. 3 of a series

"We have been using Keystone Cup Grease, No. 1 Density, Keystone Wire Cable Grease and Keystone No. 6 Density for the past two years. The No. 1 density cup grease has proven very efficient and is being used on all engine and compressor bearings in your Organ Spring Automatic compression grease cups and your Hand compression grease cups. The saving in lubrication cost is upward of 50% with less attention and no trouble or loss of time for repairs from lubrication causes.

"The No. 6 density Keystone Grease, which is fluid, has eliminated all carbon deposit, gumming and sticking of valves and explosions of our Air Compressors and we find, after fair test, that your No. 6 grease would last five times longer than the oil we used.

"The Wire Cable Grease has proved to be the only grease we have ever used, and we have tried many kinds, that would penetrate to the heart of the cable, and lubricate the inner strands, thereby practically doubling the life of the cable and the fact that we don't have to heat Keystone Wire Cable Grease in applying it saves us in labor cost 75% more than the grease cost us."

Writes a well-known manufacturer

We guarantee a saving in lubrication costs of at least 10%. In many cases the reduction is greater.

Have you talked personally with a Keystone Sales Engineer lately? We sincerely believe it will pay you to do so. So as to make sure of your hearing his message on cost reduction, we suggest that you write us here in Philadelphia, expressing your desire —*no obligation*.

KEYSTONE GREASE

I'll be at the Iron and Steel Exposition. Meet me there. Also at the International Exposition.

The Keystone Sales Engineer

Do you know any one who is paying too much for lubrication?

THEY can cut lubrication costs to the core by keeping these simple facts in mind always.

The price of a lubricant is what comes out of their pocket at the time of buying. The cost is what comes out then *and after*. The difference is what the price buyer loses; and the cost buyer saves.

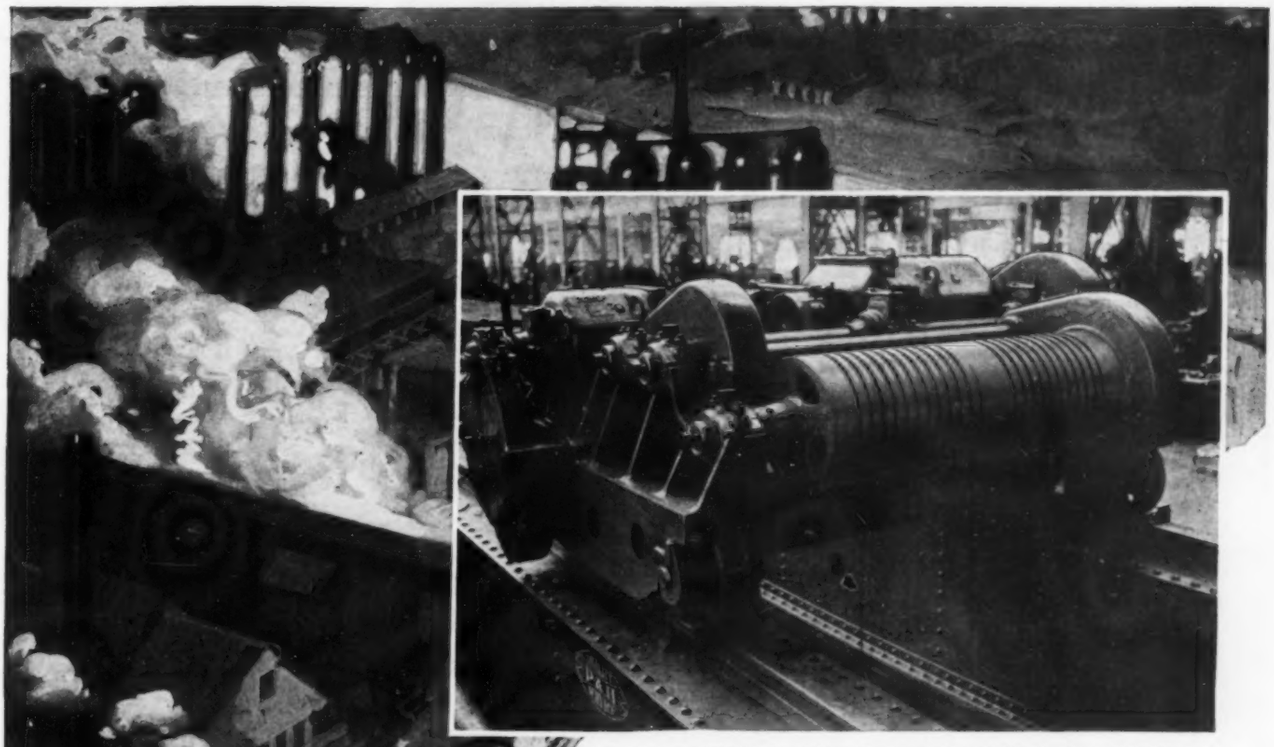
Remember! The *price* of Keystone Grease may be a trifle more in the container, but it *costs* less in the bearings. THE KEYSTONE LUBRICATING CO., *Est. 1884,* PHILADELPHIA, PA., *at 21st & Clearfield Streets.*

Keystone Grease

The Master Lubricant

For Every Industry

Reg. U. S. Pat. Off.



One of six new P & H Electric Traveling Cranes installed in the plant of the Standard Sanitary Mfg. Co., Baltimore. These cranes are required to average 104 lifts per hour.

Features That Meet Operating and Safety Requirements of the Iron and Steel Man

Here are some of the important features of this P & H Electric Traveling Crane that insure long, efficient, and dependable crane service—service demanded by the modern industrial plant.

Mill type back axle motors for Hoist and Bridge, and Trolley.

All steel construction.

Front lever safety control.

All pinions of alloy steel, heat-treated.

No overhung gears, except motor pinion.

Conductors of angle bar with ground collecting surface—mounted with 90° corner up.

Bridge and trolley truck wheels of manganese steel.

Bridge end truck brought out beyond truck wheel sufficient distance to carry vertical auxiliary girder which supports the bridge motor, platform and squaring shaft.

Exceptional lateral stiffness (required because of the rapid acceleration and reversing of the bridge). A lateral horizontal girder extends from the main box girder to the auxiliary truss.

Cap end bushings on all exterior bearings.

Wide footwalk of checkered plate extending full length of bridge side. P& H dependable quality throughout.

Visit our Booth at the Iron and Steel Exposition
DuquesneGarden
Pittsburgh
September 15th to 20th

Crane and Hoist Division

Pawling & Harnischfeger Co.

Established in 1884

3855 National Avenue, Milwaukee, Wis.

New York, Chicago, Pittsburgh, Philadelphia, Atlanta, Kansas City, Memphis, Los Angeles, Detroit, Portland, Dallas, Seattle, San Francisco

P&H CRANES and HOISTS

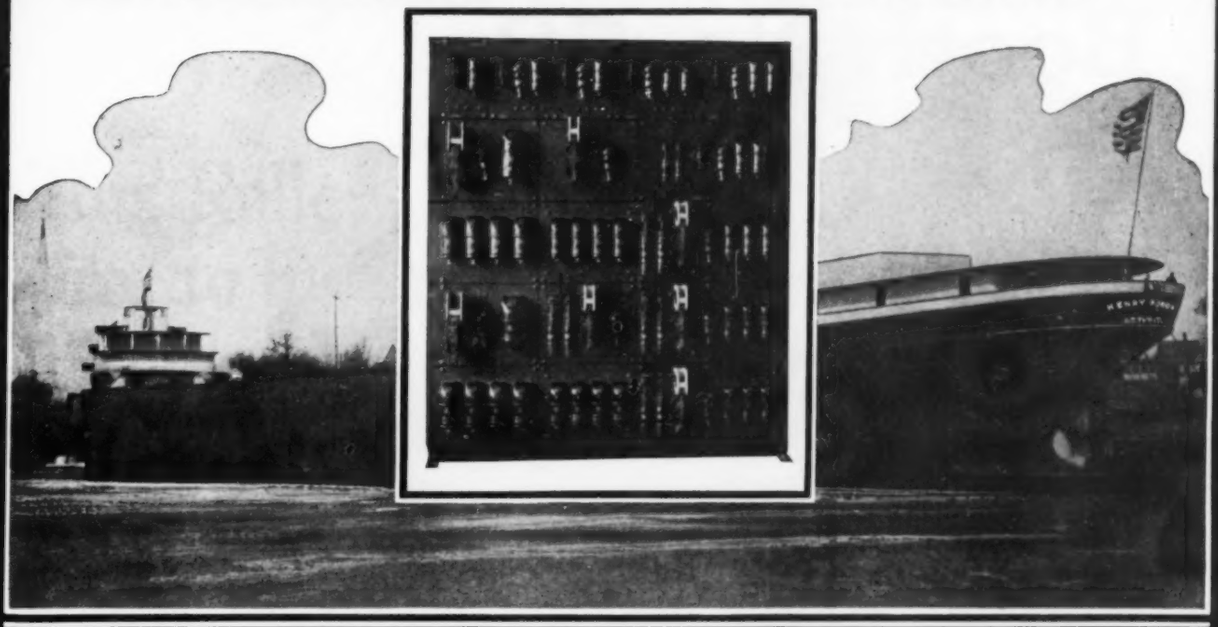
We are Distributors

of

Fostoria Mazda Lamps
Holophane Prismatic Reflectors
Square D and Trumbull Safety Switches
Galvanized and Enameled Conduit
Condulets
U. S. Rubber Paracore Wire
U. S. Rubber Royal Cord
Economy Renewable Fuses
Multiple Time Lag Fuses
Robbins & Myers Fans
Cutler-Hammer Space Heaters
Columbia Batteries
Eveready Flashlights
Dutchess Varnished Cambric Tape and Cloth
Hubbard Pole Line Material
Matthews Pole Line Specialties
Pittsburgh Transformers
Sangamo Meters
Elpeco High Tension Equipment
Lapp High Voltage Insulators
Cutler-Hammer Controlling Devices
American Blower Company Ventura Ventilating Fans and Sirocco Blowers

RUMSEY
ELECTRIC COMPANY
Electric Supplies and Machinery
Everything in Radio
1007 Arch St.
PHILADELPHIA

13 MOTORS
CONTROLLED BY THIS BOARD



The Henry Ford II, the new freighter built for the Ford Motor Co., is electrically operated throughout. Even the whistle is blown electrically.

Below decks are mounted two switchboards, one of which is shown above.

These boards are made up of EC&M Automatic Starters for starting and stopping various motors used on pumps, fans, etc.

Visit our booth at the Iron and Steel Exposition, Duquesne Garden, Pittsburgh, Pa., Sept. 15th to 20th, 1924.

THE ELECTRIC CONTROLLER & MFG. CO.

CLEVELAND, OHIO

BIRMINGHAM - BROWN-MARX BLDG.
CHICAGO - CONWAY BLDG.
CINCINNATI - 1ST NATIONAL BANK BLDG.
DENVER - 3535 WALNUT ST.
DETROIT - DIME BANK BLDG.
LOS ANGELES - THOMAS MACHINERY CO. AMERICAN BANK BLDG.
NEW YORK - 50 CHURCH ST.
PHILADELPHIA - WITHERSPOON BLDG.
PITTSBURGH - OLIVER BLDG.
SAN FRANCISCO - CALL BUILDING
SEATTLE - 524 1ST AVE. SOUTH
TORONTO - TRADERS BANK BLDG.

Welcome to Booth No. 52

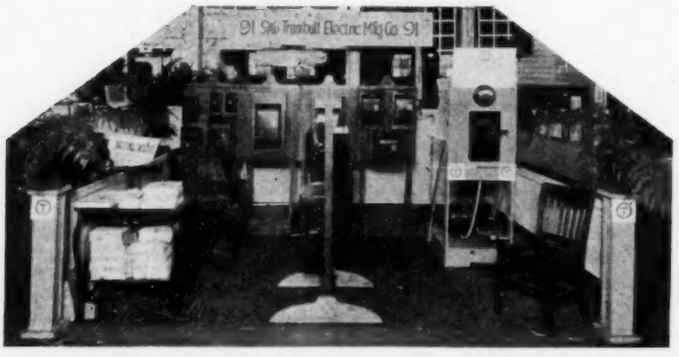


Photo of our exhibit at Buffalo last year.

Be sure and call at Booth No. 52 and look over a complete line of Safety Switches for every standard engineering requirement.

We will give you a "Circle T" Screwdriver.

WELCOME I. & S. E. ENGINEERS

The Trumbull Electric Mfg. Co.

PLAINVILLE, CONN.

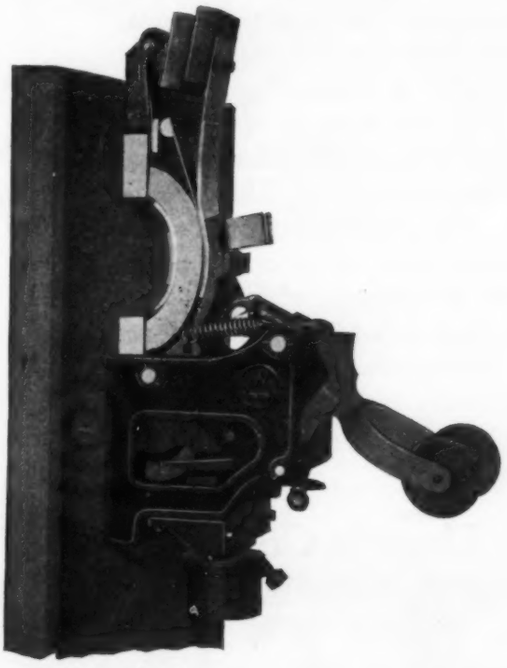
New York	Chicago	San Francisco	Boston
114 Liberty St.	2001 W. Pershing Rd.	595 Mission St.	Philadelphia
			Atlanta

Adjustment of Brush Pressure

obtained in a new and unique manner On Westinghouse Carbon Circuit Breakers

This Roller is free to turn on This Eccentric Pin

By adjusting this pin the contact pressure of the current carrying brush is increased or decreased.



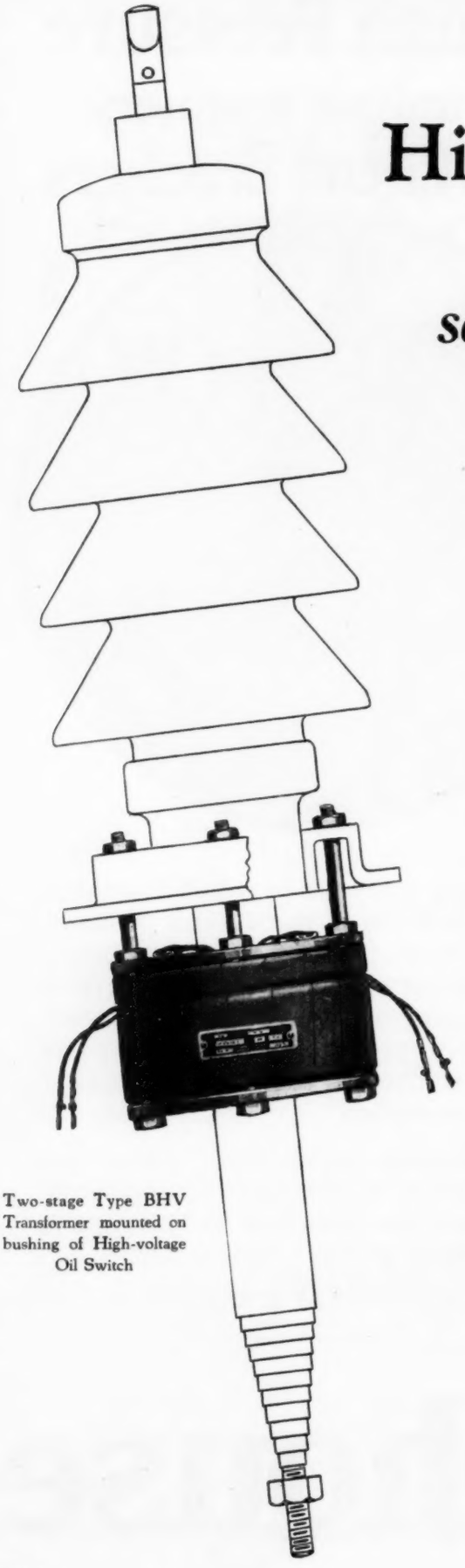
C L Carbon Breaker

A clamping screw is provided to clamp the eccentric pin in the desired position. This novel method of adjusting brush pressure is very effective, since it provides ample bearing surfaces which are necessary to prevent the loosening of the parts by deformation of the materials under shock of operation.

Other characteristics that make this breaker the most adaptable for industrial applications are described in Descriptive Leaflet 20135 and in Circular 1705.

Westinghouse Electric & Manufacturing Company
East Pittsburgh Pennsylvania
Sales Offices in All Principal Cities of the United States and Foreign Countries

Westinghouse



Two-stage Type BHV Transformer mounted on bushing of High-voltage Oil Switch

Metering High-voltage Circuits

with accuracy, safety and convenience

THE two-stage bushing-type current transformer permits electrical energy to be measured on very high-voltage lines with safety, a remarkable degree of accuracy, and at much lower cost than with the usual type of current transformer.

A ring core carrying the secondary windings is placed on a high-voltage bushing of an oil switch or power transformer connected to the line to be metered; the conductor of the switch or transformer that passes through the bushing acting as a one-turn primary for the current transformer. With this construction there is no possibility of injury to the primary conductor, nor to the secondary windings, from heavy surges or short circuits.

Although the spacing between primary and secondaries is large, the accuracy of the transformer on varying loads and with different secondary burdens is exceptionally high. This is due to the employment of the two-stage principle, which automatically compensates for ratio and phase-angle errors in the principal secondary.

Write for Bulletin No. 65, which illustrates and describes the Sangamo line of current and potential transformers, including the two-stage type of current transformer, giving typical ratio and phase-angle curves.

Sangamo Electric Company

Springfield, Illinois

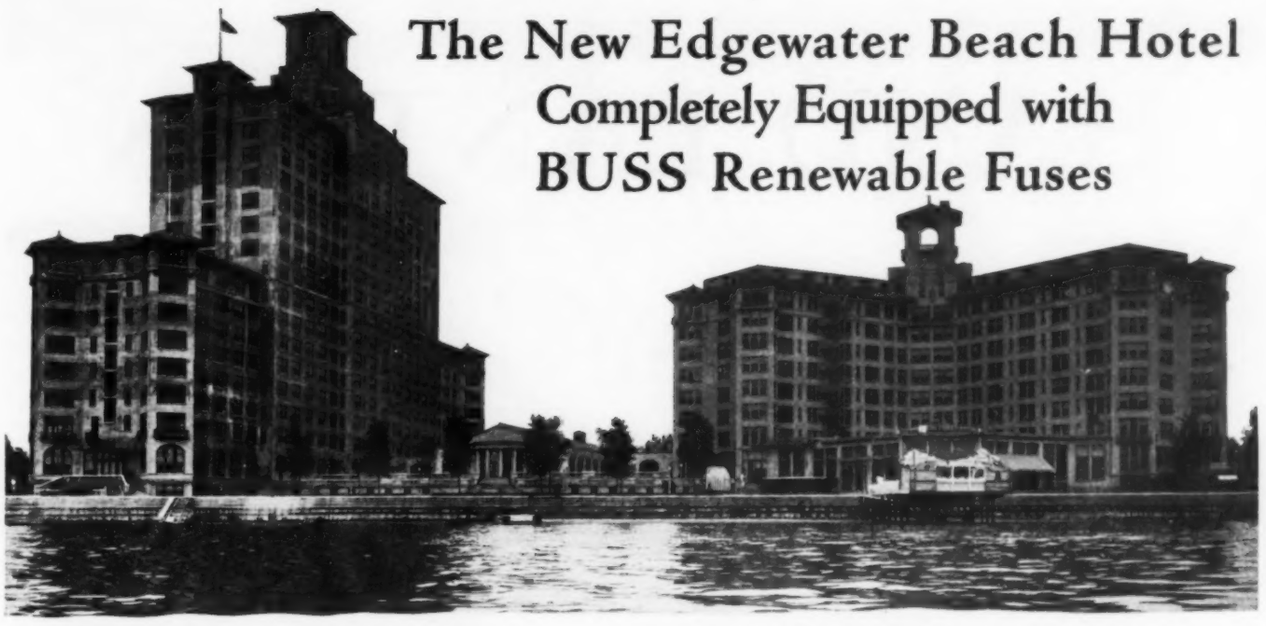
New York Chicago Birmingham San Francisco Los Angeles

Instrument transformers for every electrical need

SANGAMO

6320-S

The New Edgewater Beach Hotel Completely Equipped with BUSS Renewable Fuses



ADDITION TO EDGEWATER BEACH HOTEL

EDGEWATER BEACH HOTEL

65-600 Amperes
Knife Blade Type

SERVICE is all that any hotel can sell and in modern hotels electricity is the many handed genius who furnishes the guest with most of his comforts and necessities. The electrical circuits and apparatus must be protected against shut down at all costs.

That's why BUSS renewable fuses were chosen to protect the circuits of this wonderful new addition to the Edgewater Beach Hotel. BUSS design and construction is such that to renew a BUSS fuse is but the work of a few seconds and faulty renewal is almost impossible. By practically eliminating faulty renewal (the greatest cause of poor contact) BUSS has removed the cause of most premature and unnecessary blow outs and has added years to the life of the renewable fuse.

If you are not thoroughly acquainted with BUSS construction fill in the coupon and let us send you a sample.

3 Parts and the Link THAT'S ALL!

BUSS FUSES

APPROVED IN ALL TYPES AND SIZES

TRADE BussFuses "ELECTRICITY'S SAFETY VALVE" MARK REG U.S. PAT. OFF.

"ELECTRICITY'S SAFETY VALVE" MEANS ON

BUSSMANN MANUFACTURING CO. I. & S. E. 9-24
3819 North Twenty-Third Street, St. Louis, Mo.
Without obligation, send me for examination sample 100 ampere, 250 volt Knife Blade Type BUSS Renewable Fuse.

Name
Position
Company
Street
City
State

HAND LANTERN

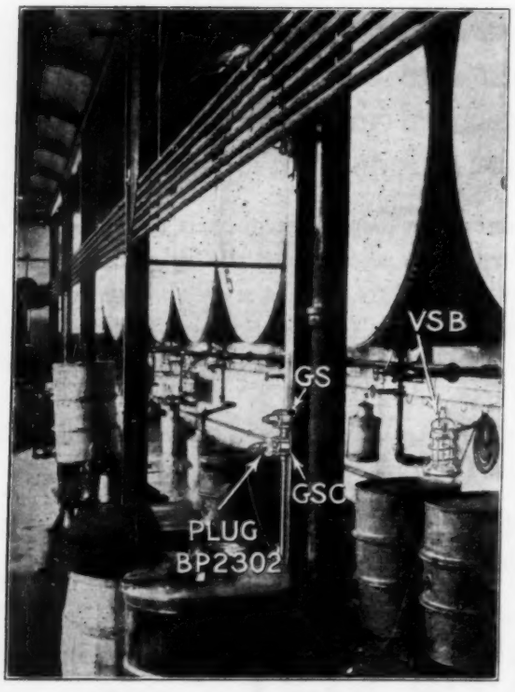
TYPE VSB

Takes 75-Watt Mazda C Lamps or Smaller

VAPORPROOF

Has Heavy Brass Base
Cannot Be Easily Upset

TYPE VSB



OIL WAREHOUSE
A Condulet Installation and Electric Hand Lantern

For Use in Oil Derricks,
Oil Warehouses, Garages or
similar places, or
Where Explosive Gases and
Vapors are present.

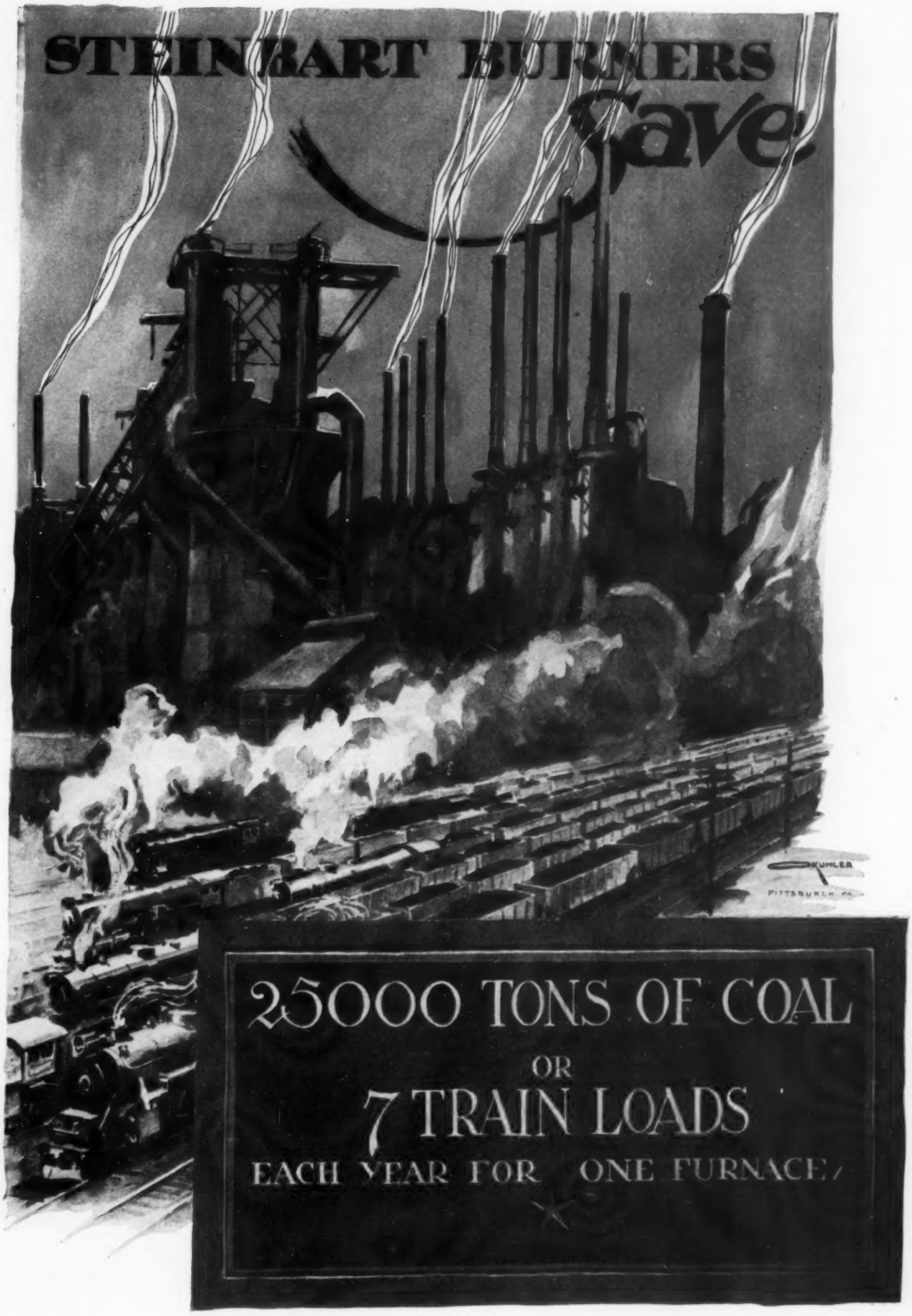
Listed and Described in Detail in Bulletin 2051

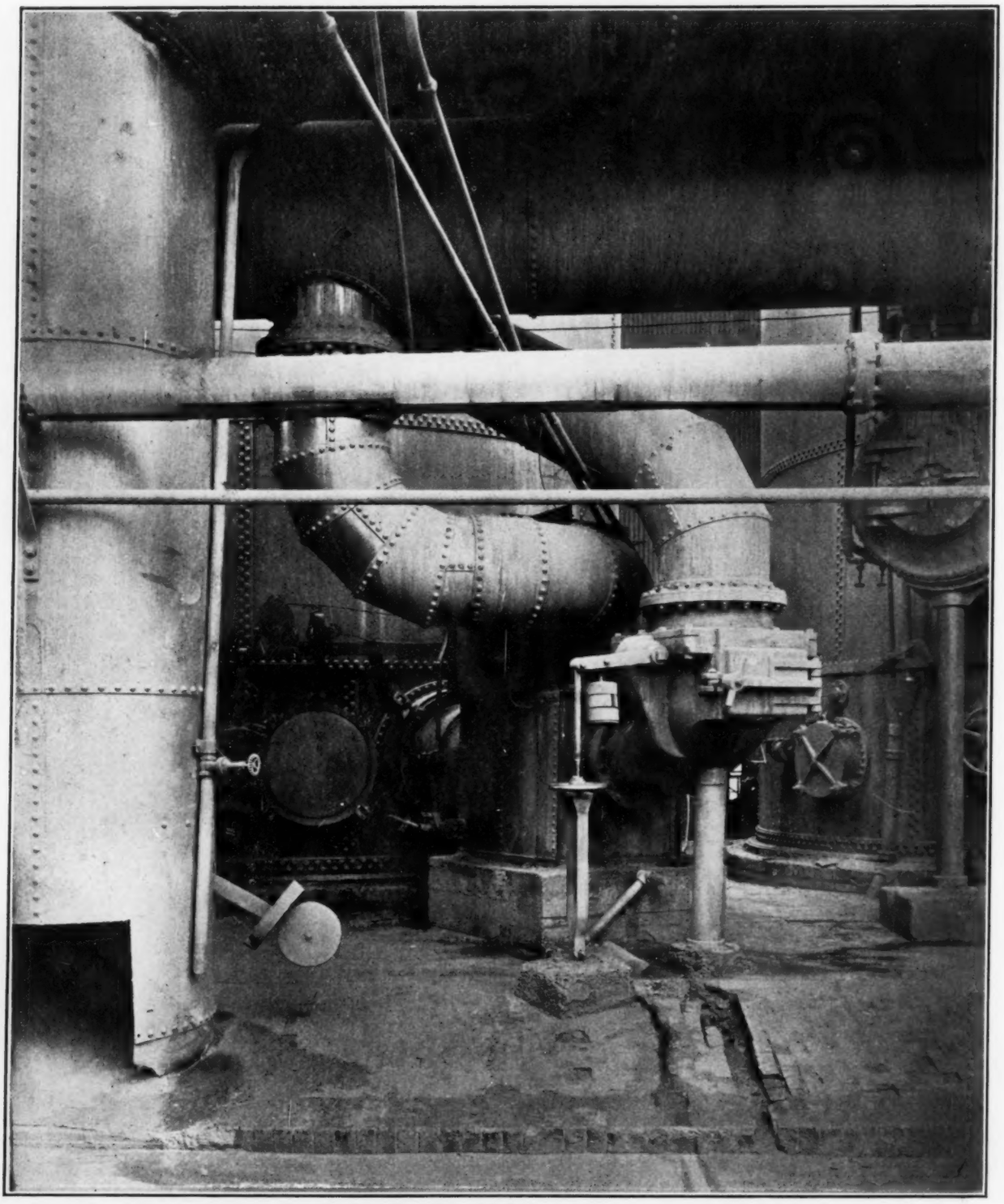
CROUSE-HINDS COMPANY
SYRACUSE, N. Y., U. S. A.

SALES OFFICES
NEW YORK BOSTON CHICAGO
PHILADELPHIA DETROIT ST. LOUIS MINNEAPOLIS
CINCINNATI SAN FRANCISCO

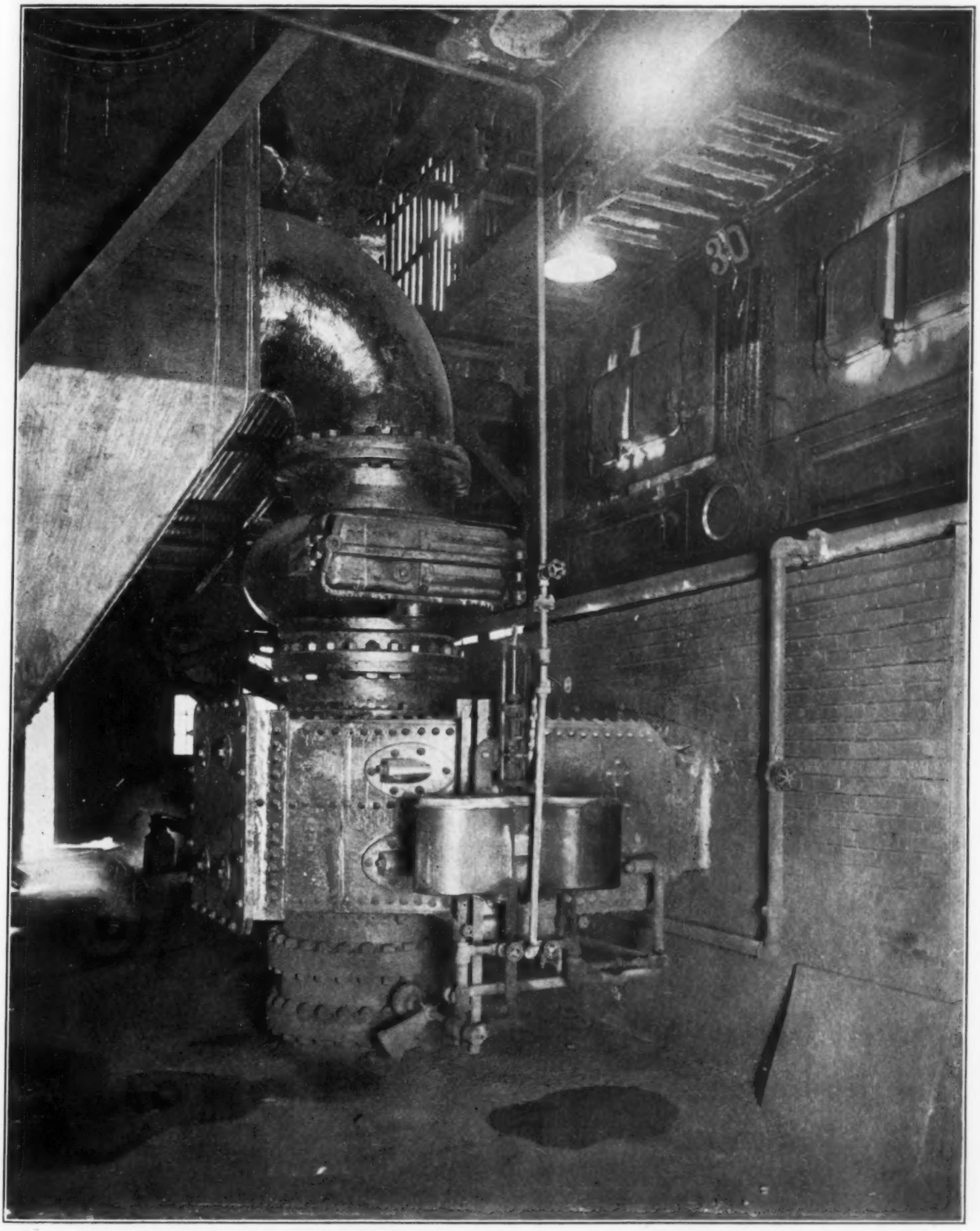
FT 136

CROUSE-HINDS


STEINBART BURNERS
Save
25000 TONS OF COAL
OR
7 TRAIN LOADS
EACH YEAR FOR ONE FURNACE



Close Up of One Stove Equipped with Steinbart Patent Pressure Burner at Shenango Furnace Co., Sharpsville, Pa.



Steinbart Boiler Burner Installation at Wheeling Steel Corporation, Steubenville, Ohio.

WHAT STEINBART BURNERS WILL DO FOR YOU

ON STOVES

Reduce your gas consumption
by from 20 to 30%

Enable you to carry
higher blast heats

ON BOILERS

Permit you to run your boilers on ratings up to 300%, thus saving boiler equipment.

Increase your evaporation from gas by from 20 to 50%.

Eliminate all regulation dependent on human intelligence.

For full particulars write to

AMERICAN HEAT ECONOMY BUREAU, Inc.

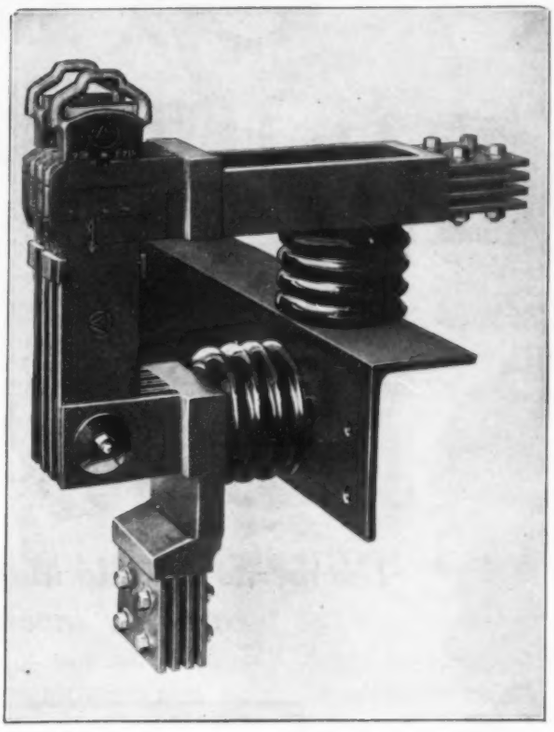
926-930 WABASH BUILDING
PITTSBURGH, PA

THE STANDARD OF COMPARISON

The Delta Star

UNIT TYPE

4000 Amp. Disconnect



Easily Installed

Low Cost Simple

Quick Shipments

The Utmost in Value

THE thing that has set "Unitype" apart from every other high tension equipment made is **real design.** Delta-Star "Unitype" equipment has for years held an unassailed position in the high tension field and is an acknowledged standard.

DELTA-STAR ELECTRIC CO.

2400 Block Fulton St Chicago, Illinois

Birmingham, Ala., 827-830 Brown-Marx Bldg.
Boston, Mass., 294 Washington St.
Buffalo, N. Y., 595 Ellicott Square
Charleston, W. Va., The Eng'g Service Co.
Columbus, Ohio, 600 Joyce Realty Bldg.
Detroit, Mich., 708 Ford Bldg.
Indianapolis, 518 Trac. Term. Bldg.
Kansas City, Mo., 301-2 Dwight Bldg.
Knoxville, Tenn., Holston Nat'l Bank Bldg.
Los Angeles, Calif., I. W. Hellman Bldg.
Minneapolis, Minn., 940 Security Bldg.
New York, N. Y., 25 Broad St.
Orlando, Fla., Cornell-Mathews Co.
Philadelphia, Pa., 1333 Real Estate Trust
Pittsburgh, Pa., 934 Union Trust Bldg.
Rochester, N. Y., 119 Main St., E.
Salt Lake, Utah, 313 Dooly Bldg.
San Francisco, Calif., 193 Second St.
Seattle, Wash., Hoge Bldg.
St. Louis, Mo., Railway Exchange
Syracuse, N. Y., City Bank Bldg.

UNIT TYPE CEMENTED SWITCH INSULATORS

5 OHIO LIFTING MAGNETS

recently sold to the Brown Hoisting Machinery Co. for use on five of their locomotive cranes by the Chesapeake & Ohio R. R. Co.

The merits of Ohio Magnets were most carefully investigated

We will be glad to see you at Booth 18, A. I. & S. E. E. Convention.

The Ohio Electric and Controller Co.

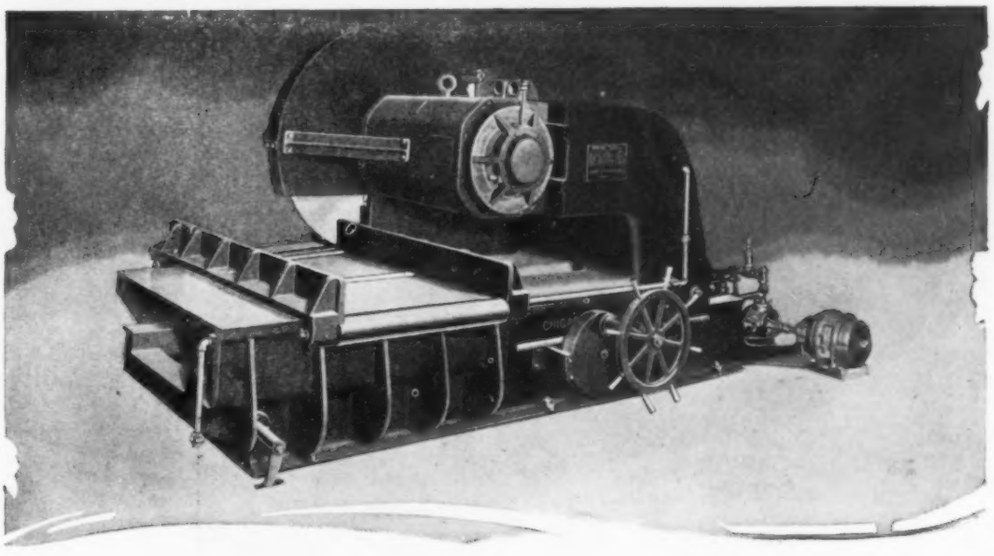
Cleveland. Ohio

OR ASK OUR REPRESENTATIVE

OHIO reliable MAGNETS

G. H. Armstrong, 317 First National Bank Bldg., Cincinnati, O.
Hunter L. Betts, 406 So. Franklin St., Syracuse, N. Y.
K. I. Clisby, Woolworth Bldg., New York City, N. Y.
S. G. Elbe, 211 Tramway Bldg., Denver, Colo.
A. J. Haywood, 88 Broad St., Boston, Mass.
Holden Company, Ltd., 350 St. James St., Montreal, Canada; 342 Adelaide St., West Toronto, Canada; 150 Princess St., Winnipeg, Canada; 81 Pender St., West Vancouver, B. C.
Howard & Geeseka Co., 826 Plymouth Bldg., Minneapolis, Minn.
H. A. Killam, 312 McKay Bldg., Portland, Ore.
A. S. Lindstrom, 111 New Montgomery St., San Francisco, Cal.
G. H. Maire, 95 Connecticut St., Seattle, Wash.
Charles J. Mundo, 364 Union Trust Bldg., Pittsburgh, Pa.
Linn O. Morrow, 811 Schaff Bldg., Philadelphia, Pa.
Nixon-Hassele Co., Chattanooga, Tenn.
J. R. Petree, 305½ Mutual Life Bldg., Buffalo, N. Y.
Southern Industrial Engineering Co., Birmingham, Ala.
C. H. Stem, Audubon Bldg., New Orleans, La.
D. O. Stewart, 619 Bank of Commerce Bldg., St. Louis, Mo.
W. H. Williams, 53 West Jackson Blvd., Chicago, Ill.

SKF



No Motor Bearing Repairs
Necessary on this Giant Friction Saw

JUST a few seconds—the sharp whine of steel—and the job is done on this giant friction saw, no matter what the size—from steel rails to gigantic bars. The use of Hess-Bright Deep-Groove Ball Bearings on the 125-250 H. P. motor, operating at 1,800 R. P. M. insures economical and dependable operation in this hard service.

They take both radial and thrust loads in combination without discernible wear even after years of hard grind and maintain original settings indefinitely. Sealed housings exclude foreign substances from the bearings and prevent oil leakage on motor windings. Perfect motor performance with no danger of costly shutdowns always assured.

THE HESS-BRIGHT MANUFACTURING COMPANY

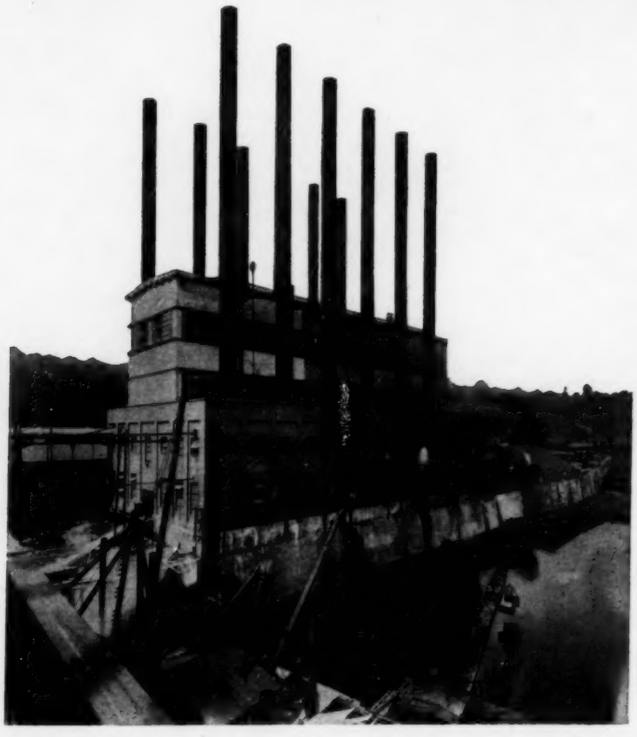
Supervised by SKF INDUSTRIES, INC., 165 Broadway, New York City

1233

Cross Section of Single-Row Bearing

Cross Section of Double-Row Bearing

LADD
WATER TUBE BOILERS



NO matter what your local conditions of size, space, fuel burning equipment or other limitations may be, there's a specially designed type of LADD WATER TUBE BOILER to meet your requirements.

LADD BOILERS have been built varying from 25 H.P. to 120 H.P. per foot of furnace width, and may be operated with any type of modern stoker equipment, with Blast Furnace or Natural Gas, with Powdered Coal or various combinations of these fuels.

The simple yet rugged construction and design—which makes every part of the boiler easily accessible—the rapid, unrestricted circulation and properly designed and proportioned gas passages makes the LADD BOILER perform its functions in a satisfactory, highly efficient and workmanlike manner. Our installations are our best talking points.

Write for our latest bulletin.

THE GEORGE T. LADD COMPANY

First National Bank Building
PITTSBURGH, PENNA.

CHICAGO OFFICE
528 McCormick Building

PHILADELPHIA OFFICE
502 Franklin Bank Building

NEW YORK OFFICE
39 Cortland Street

WATER TUBE BOILER LADD

Dust-Tight Heavy Duty Unit

For Steel Mills and Foundries

Showing the New Benjamin Dust-Tight Glass Cover on 14' R.L.M. Reflector Unit with Type RR Cast Hood.

BENJAMIN

extends a cordial invitation to the members of the Association of Iron and Steel Electrical Engineers to visit its display of mill and foundry and heavy duty industrial lighting and other electrical equipment at

Booth No. 79

DUQUESNE GARDEN

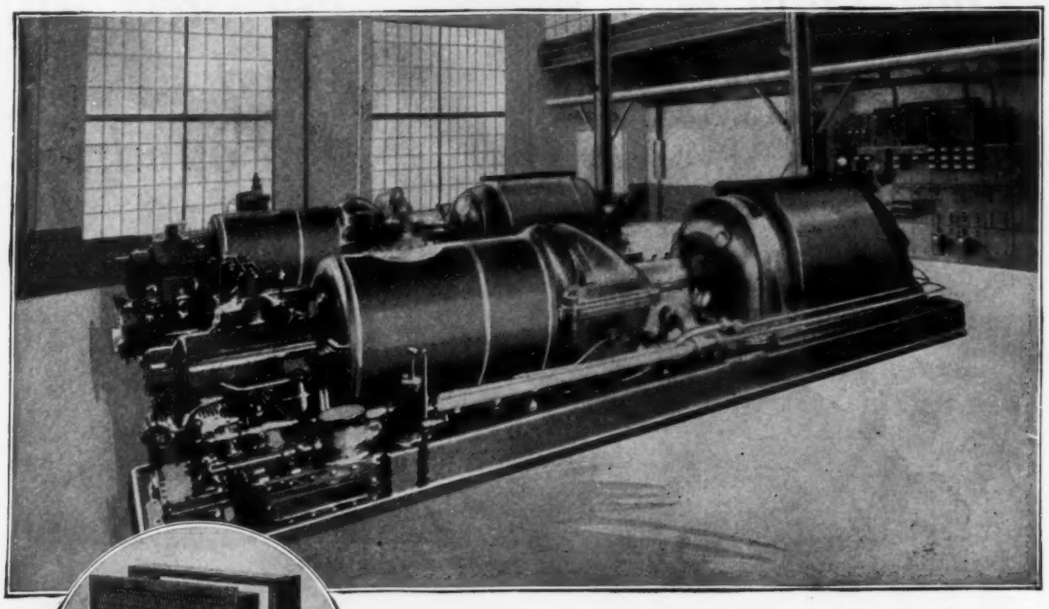
Pittsburgh, Pa. · · September 15 · 20, 1924

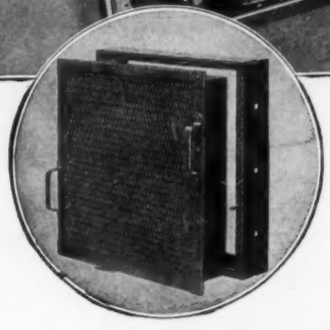
The convention and exhibit give us an opportunity which we greatly appreciate to meet many friends in the metal industries at close range. We will be especially pleased to show you many Benjamin specialities particularly adapted to your requirements, including the New Dust-Tight Glass Cover for Reflectors, for Steel Mills and Foundries, the Type RR Heavy Duty Threaded Reflector Units, Reflectors of all kinds, Electric Signals, Heavy Duty Attachment Plugs, Shock Absorbing Fittings, Watertight and Dust-Proof Lighting Equipment, Heavy Duty Sockets, Acid Resisting Lighting Units, etc.

Benjamin Electric Mfg. Co.

NEW YORK CHICAGO SAN FRANCISCO

REED AIR IS CLEAN AIR





Electrical Machinery Requires Clean Air

The Reed System of Air Filtration supplies clean air at minimum cost. Its best endorsement is the number of large electrical organizations that have installed Reed Air Filters after careful investigation.

These installations include the ventilation of turbo generators, sub-stations, air blast transformers, mill motors, bus galleries, etc.

Let us make this Free Test

Our nearest representative will be glad to make the authoritative E. Vernon Hill Test of your air conditions. No obligation.

American Gas & Electric Co. *Marion Ind. Scranton, Pa. Rockford, Ill.*
American Steel & Wire Co. *Cleveland, Ohio*
Columbia Steel Corp. *Springville, Utah*
Commonwealth Edison Co. *Chicago, Ill.*
Compania Azucarera Baragua *Baragua, Cuba*
Desloge Consolidated Lead Co. *Desloge, Mo.*
East Penn Power Co. *Pine Grove, Pa.*
Electric Service Co. *Dodge City, Kansas*
Kanaas City Power & Light Co. *Kansas City, Mo.*
Kansas Public Utilities Co. *Fort Scott, Kansas*
Producers & Refiners Corp. *Parco, Wyoming*
Rochester Gas & Electric Co. *Rochester, N.Y.*
Northwest Paper Co. *Cloquet, Minn.*
Sandusky Gas & Electric Co. *Sandusky, Ohio*
Southern Paper Co. *Moss Point, Miss.*
Union Gas & Electric Co. *Cincinnati, Ohio*
Union Electric Lt. & Power Co. *St. Louis, Mo.*
United Electric Lt. & Power Co. *New York, N. Y.*
Water & Light Commission *Virginia, Minn.*

REED AIR FILTER COMPANY, Inc.
213 Central Ave., Louisville, Ky. 50 Church St., New York City

Offices in Principal Cities

REED AIR FILTER COMPANY, Inc.
Engineering Department
213 Central Ave., Louisville, Ky.

Gentlemen: Please send me without obligation your informative folder, "Are You Interested in Clean Air?"

Application.....C.F.M.

Name.....

Address.....

Reed Air

TRADE *filters* ALL METAL MARK

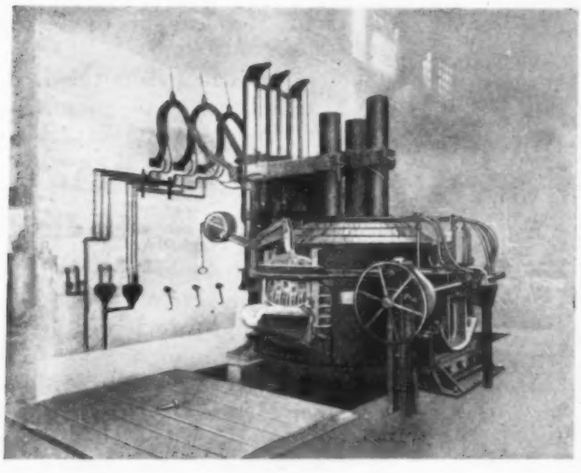
Note: SIGN ON THE "REED AIR" DOTTED LINE FOR CLEAN AIR AT MINIMUM COST

MOORE RAPID FURNACES

'Lectromelt

LET US DISCUSS YOUR ALLOY—TOOL STEEL—IRON AND STEEL CASTING PROBLEMS AT THE

A I & S E E



CONVENTION

Duquesne Garden—September 15-19

PITTSBURGH, PA.

BOOTHS 70-71

'Lectromelt furnaces are built in standard sizes ranging from 125 pounds up to 24 tons per heat.

PITTSBURGH ELECTRIC FURNACE CORPORATION

PITTSBURGH, PA.

OFFICES IN ALL PRINCIPAL CITIES

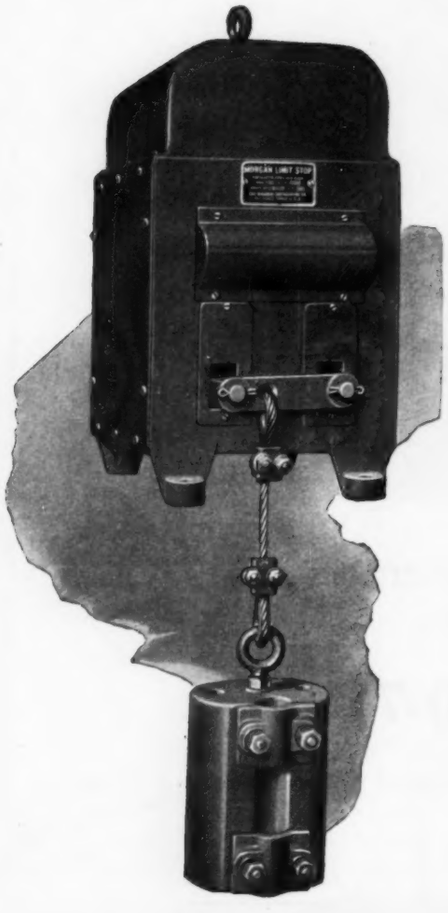
MORGAN

SAFETY LIMIT STOP

WACKERLY TYPE

A NEVER FAILING HOIST LIMIT STOP

For All Types of Direct Current Motors



A FEW OF THE MANY ADVANTAGES

No heavy current broken by contactors.

Limit Stop can be connected up with any standard make of controller.

No extra conductors required.

Normal lowering circuits established immediately upon reversal of controller. No waiting to lower through resistance.

No external banks of resistance. Limit Stop is self contained.

Only one swinging weight used, this being guided by one of the hoisting ropes.

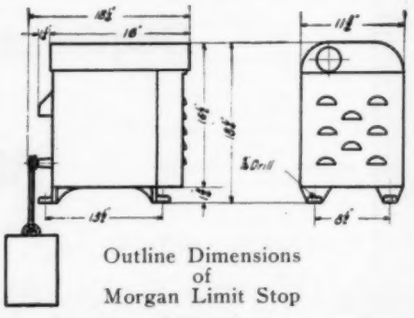
Positive in action. A movement upward of weight of a fraction of an inch will actuate limit stop.

Occupies minimum floor space on trolley.

Sequence of operation of contactors obtained by simple system of levers. No cams, springs or counterweights used.

For full particulars on this stop send for Bulletin No. 29

See this Stop in operation at the Iron and Steel Exposition.



Outline Dimensions of Morgan Limit Stop

A total movement of weight of less than one inch required for complete functioning of stop.

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Alliance, Ohio

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Electric Traveling Cranes, Rolling Mill Machinery
Ordnance, Steel, Shipbuilding and Forging Plants Complete
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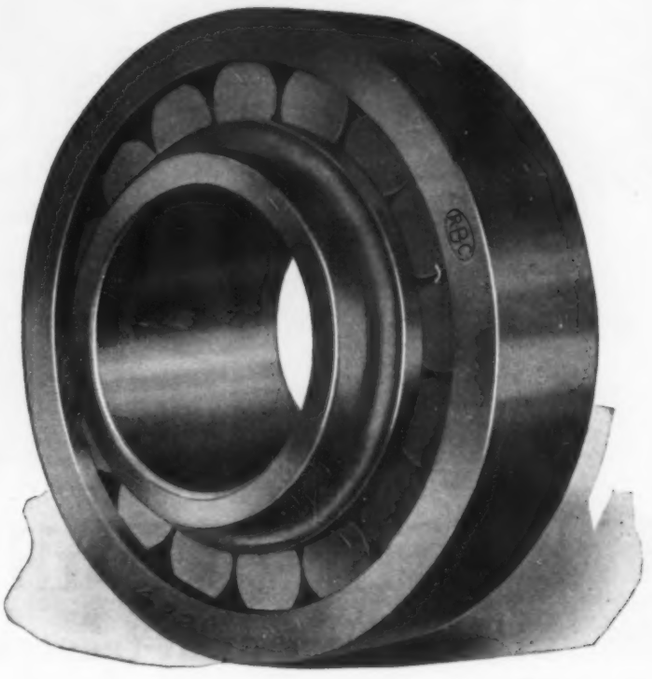
A
Sewing Machine Motor
won't handle
A 10 Ton Crane
Even if both are electric



Neither are all Anti-Friction Bearings
Heavy Duty Bearings

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are a specialized product designed to serve under the severest conditions.

The "ROLLWAY" Maximum types have the greatest possible radial capacity plus the necessary built-in safety factor to take care of the shock loads that are ever present.

Long life is insured by the use of the finest alloy steel scientifically heat treated.

Thousands installed in steel mill equipment bear testimony of these facts.

Detailed information on "ROLLWAY" equipment for any type of machine or motor used in steel mill service on request.

Write for Catalogs.

Made in

SYRACUSE, NEW YORK, U. S. A.

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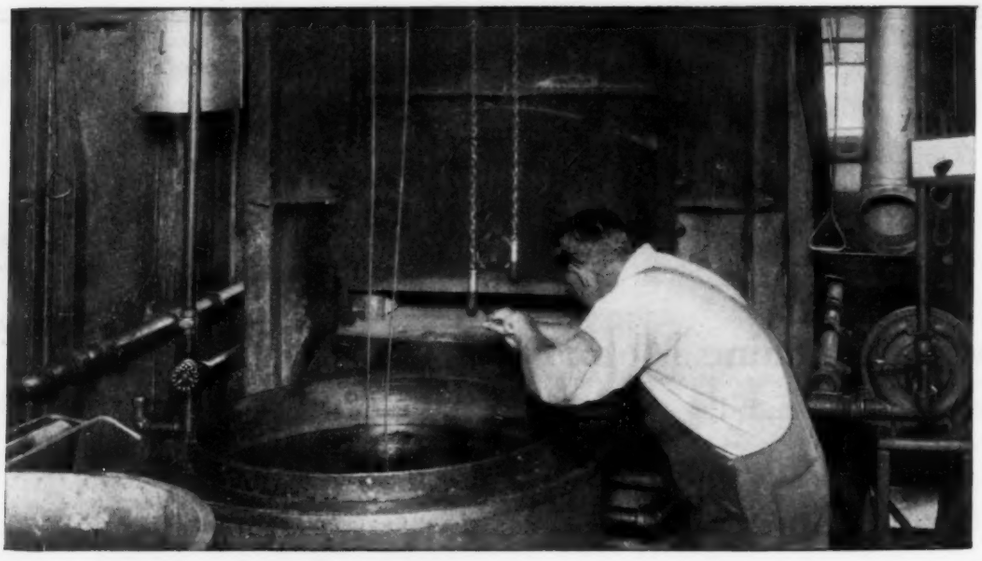
ROLLWAY BEARING CO., Inc.



Double-acting thrust bearing, flat seats (grooved races) 2100-F Series

Single-acting thrust bearing, flat seats (grooved races) 1100-F Series

Single-acting, self-aligning thrust bearing 1100 Series

Single-acting, self-aligning thrust bearing, leveling washer. 1100-U Series

Double-acting, self-aligning thrust bearing, leveling washers 2100-U Series

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are heat-treated throughout not merely case-hardened

STROM Ball Bearing race rings are made of special high carbon chromium steel produced in electric furnaces. They are machined from solid bars, tubes and forgings, as required, and hardened throughout by heat-treating to insure uniform hardness, elasticity and durability.

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The balls used in Strom Ball Bearings are Strom-made of chrome alloy steel, accurate to size within .00005" and sphericity less than .000025".

Strom Ball Bearings are made in a wide range of types and sizes to meet every ball bearing requirement. They are standardized and interchangeable with other standard bearings.

Large stocks of all types and sizes are always kept on hand to meet emergency demands.

Write for catalogue, price lists, load capacities at various R.P.M. and other informative literature. We shall be glad to assist in solving your bearing problems.

Strom BALL BEARINGS

STROM BALL BEARING MFG. CO.
Formerly U. S. Ball Bearing Mfg. Co.
4594 Palmer Street, Chicago, Ill.

Single-row deep-groove Standard type, radial bearing

Double-row, deep-groove Standard type, radial bearing

Angular contact bearing, combination radial and thrust

Double-row, maximum type, radial bearing

Single-row, maximum type, radial bearing

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Pyle-O-Lytes
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THE PROFITABLE EXHIBIT

No. 41

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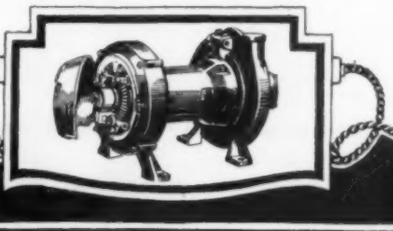

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204 of 100 Tons Capacity and Over

STANDARD CRANES

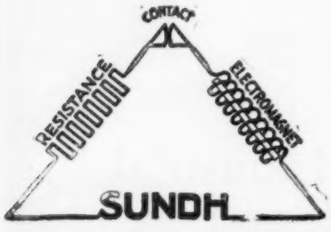
55	100 tons
2	115 tons
42	125 tons
24	150 tons
22	175 tons
2	200 tons
1	225 tons
1	250 tons
3	430 tons

STRIPPING CRANES

8	100 tons
1	125 tons
19	150 tons
13	200 tons
1	Single Ram, 320 tons

COMBINATION CHARGERS AND STRIPPERS

3	100 tons
3	150 tons
4	200 tons



Steel Men!

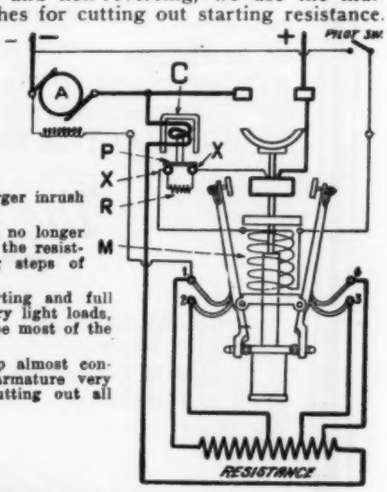
Isn't this what some of you wanted, as brought out in your discussion of control in your Journal of November, 1921? A control that would have definite time limit modified with current limiting element?

You want a starter to obey its real function, don't you? i. e., to start and accelerate a motor by cutting in resistance, then out, in the shortest possible time in relation to the load. You want the motor to "mote" if it's at all possible to do so, whether the voltage is high or low, or whether there is excessive friction on a cold Monday morning. If the first current inrush does not start it, the next one may. If we can't get it to start on small amounts of current, we want to provide automatic means of increasing the current or power so that it will start, provided that no one has placed a crowbar in between the gears or there happens to be a short circuit. In that case, overload circuit opening devices take care of the condition.

We have been using this method since 1911. On large size motor starters, reversing and non-reversing, we use the multiple level starter as a pilot relay whose multi-contact energizes large shunt wound switches for cutting out starting resistance.

The action of this control is easily understood from the diagram, and the following description of operation:

The relay C is in series with the armature only during the starting period and is normally set to operate at about 130% of normal current. When the current in the armature of the motor equals or exceeds this setting on the starting inrushes, the armature of the relay lifts the plate P from the two contacts XX and by this action inserts the resistance R in series with the solenoid coil M of the automatic starter. The resistance R can be made to have a resistance so that when inserted in the circuit of the coil M (by action of excess load on the armature of motor at start) it partly destroys the effective magnetic pull of coil M and prevents the cutting out of any more resistance in the armature circuit, but at the same time there is sufficient magnetic pull to lift the core very slowly so that in time, even with the insertion of this resistance in the magnet coil circuit, the next succeeding step of resistance will be cut out, giving a larger inrush current to the motor.



Under normal conditions as soon as the current in the armature reduces to about normal, the coil C can no longer hold up plate P and it consequently drops, thus closing the circuit across contacts XX, and short circuiting the resistance R, allowing coil M to be again fully energized and to act with full power, thus cutting out succeeding steps of resistance quickly.

The retarding action caused by excess load on coil M may take place during any interval between starting and full running position. The time of the dash pot is generally set for a minimum of 1½ seconds. which in case of very light loads, the cutting out of resistance would take approximately this time, since the series relay coil C plate XX, would be most of the time short circuiting the resistance R.

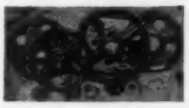
Under abnormal, extremely heavy loads, where the series coil C would lift its armature and hold it up almost continuouly, thus inserting all the resistance in the coil, R circuit on automatic starter coil M would lift its armature very slowly against the action of the dash pot and light pulling force, and may take up to 15 seconds before cutting out all resistance.

The resistance R may be made of a value as to either increase or decrease the pull of magnet coil M.

Write for Catalog.

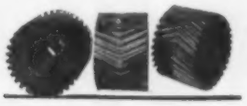
SUNDH ELECTRIC COMPANY Newark, N. J., U. S. A.

Herringbone Mill Pinions



Motor and Crane Gears

Mill Table Gears

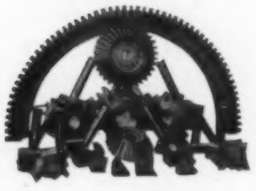


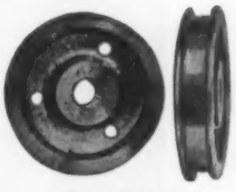
Herringbone Gears

Tool Steel Face
as hard here as on the very surface. (This is one of the great differences between tool steel and case-hardening methods)
Toughened Center

Cincinnati "Tool Steel" gears outlast 8 to 10 Untreated and are much stronger

Coupling Boxes and Spindles





Crane Wheels

The Tool Steel Gear and Pinion Company

CINCINNATI, OHIO

Bulletin No. AK450

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TRANSFORMERS

WE have been manufacturing transformers now for over a quarter of a century—a long time in an industry so young.

Moloney Engineering Experience has dealt with the transformer in every phase of its development.

From the first, Moloney Engineers have been animated by a two-fold purpose: to build the highest attainable quality, and to build it economically.

Moloney Transformers are recognized by all transformer users as the highest standard—a fact which demonstrates the success which has crowned the efforts of Moloney Engineers.

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Manufacturers of Transformers Exclusively
FACTORY AND MAIN OFFICE
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Better Yard and Plant Hauling

Ironton Storage Battery Locomotives meet perfectly the hauling conditions in the yards and plants of many steel mills. Dependability, low power cost, simplicity—are its big advantages. Irontons operate 24 hours a day.

Let Ironton engineers study your conditions and make you a guaranty of Ironton Performance under your conditions.

The IRONTON ENGINE CO.
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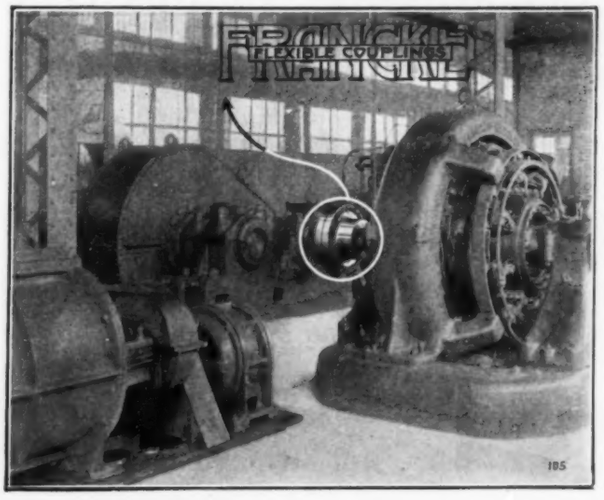
FRANCKE
FLEXIBLE COUPLINGS

"They make good machines last longer"



Francke flexible couplings save needless installing and operating-trouble costs. They are flexible in all directions. They are all-metal and durable. And in addition they provide a spring cushion for load shocks, vibrations, etc.

As with any coupling, the shafts should be lined up accurately when installed. With a Francke this is quite easy. Simply use a straight edge across the flanges at three points each about 90 degrees apart, and also measure the spacing between flanges at similar points.

To take care of all of the conditions usual with the many kinds of direct drives there are five different types of Francke flexible couplings—sizes to transmit from ¼ H.P. to 8,700 H.P. Depending upon operating conditions, some of these should be lubricated. In most cases a Francke needs no other attention after it is installed.

By removing the strains otherwise resulting from misalignment and by providing a spring cushion for shocks, Francke flexible couplings make good machines last longer.

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SMITH & SERRELL

Coupling Specialists Since 1912.

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Nothing but a Screw Driver needed

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"Union" Fuses are never balky. Metal parts are too far from the fusing point to corrode. And there's no inner cartridge to swell, so they can't stick.

Heavy, rugged design gives "Union" Renewable Fuses the longest mileage.

These are the reasons why

The "UNION" saves more than ANY other renewable fuse

"Union" Renewable and Non-Renewable Fuses are sold by electrical jobbers and dealers. Send for our new 96-page Catalog. It gives lots of facts about fuses.

Chicago Fuse Mfg. Co.

Manufacturers also of Switch and Outlet Boxes, Cut-Out Bases, Fuse Blocks, Fuse Wire and Automobile Fuses

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UNION REG.U.S. PAT.OFF

'UNION' FUSES

RENEWABLE & NON-RENEWABLE

The **NEW**

TRICO

Handy Pocket Size

FUSE PULLER *and* **REPLACER**

For All Fuses
up to
200 A. 250 V.
and
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Made of the highest grade genuine Gray Horn Fibre, tested at 35,000 volts.

A Lifetime of Safety First Service

ONLY

$1.00

In U. S. A.

Discounts
In Quantities

Actual Size
7½ Inches Long

The many years of excellent service of this tool divided by its small initial cost makes the annual cost so low that "every fuse or switch box should contain one."

TRY ONE—YOU'LL WANT MORE
Write for name of nearest dealer.

Made by TRICO FUSE MFG. CO., Milwaukee, U. S. A.

TRICO FUSES
Renewable Cartridge

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Worcester, Mass., U.S.A.

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Morgan Continuous Mills

for

Billets, Sheet Bars, Skelp, Merchant-Bars, Hot-Strip, Rods

also

Wire Drawing Machines
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Our Engineering Department

is prepared to solve successfully your problems in design or arrangement of plant and equipment from open hearth to finished product

1891 — 1924

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WESTINGHOUSE serves users of Westinghouse motors not only through the quality built into the product, but also through—

Expert Engineering Counsel, when desired, based both on thorough electrical knowledge and on practical experience with the varied requirements of industry.

Twenty-six Service Shops—so located as to be within a night's journey from any industrial center, and equipped for either normal or emergency requirements.

Twenty-Nine Warehouses—carrying reserve stocks of motors of all popular ratings, as well as renewal parts which are immediately available.

Ninety-One Offices—within reasonable telephone distance from any town in the United States.

Jobbers and Dealers Everywhere—authorized to sell Westinghouse products because they are *organized to serve* Westinghouse users.

An Ultra Modern Factory—at Homewood, Pa.—dedicated solely to giving emergency service on renewal parts.

The completeness and accessibility of Westinghouse Service has no parallel. Ask any experienced user.

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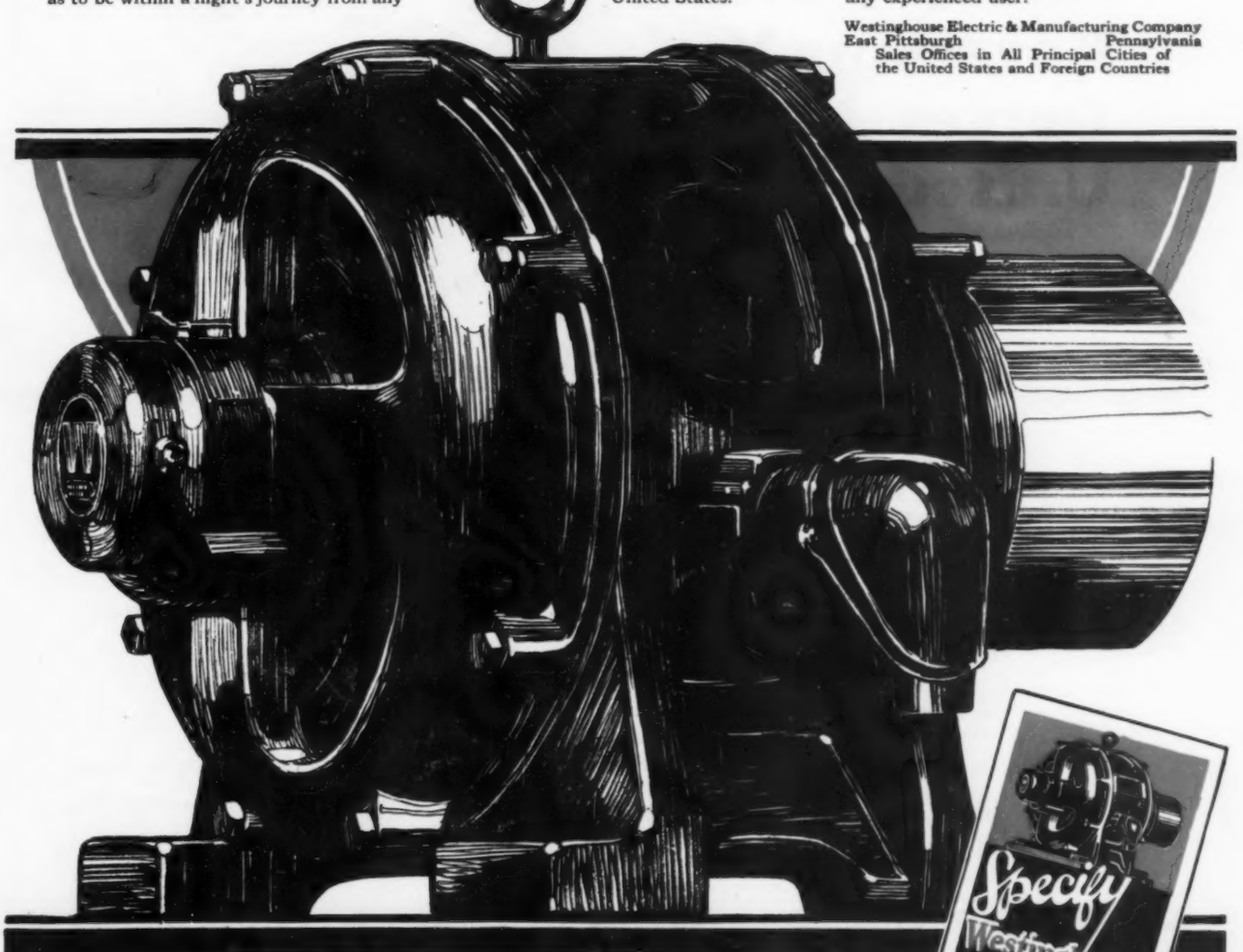
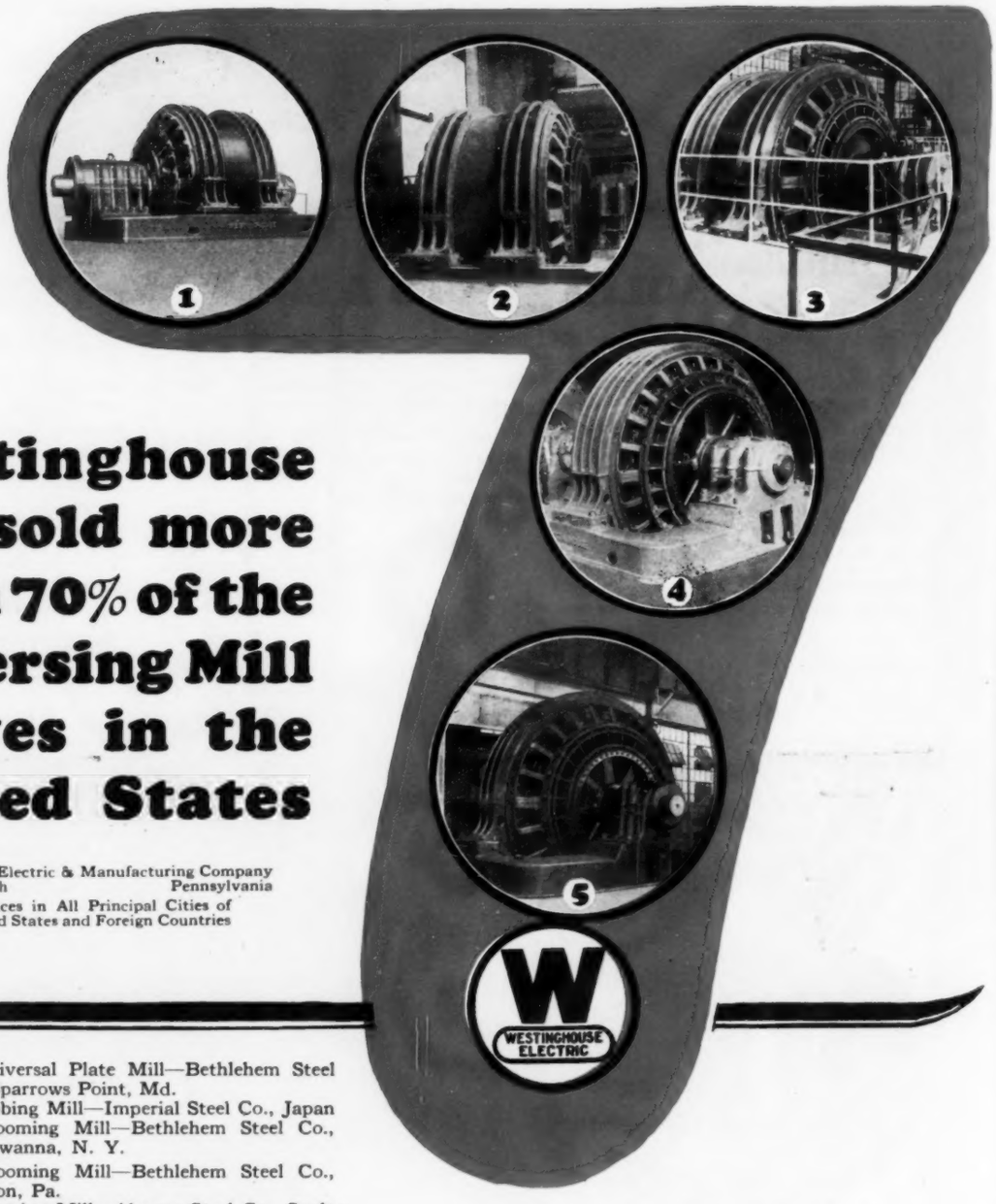
Sales Offices in All Principal Cities of the United States and Foreign Countries



Westinghouse



Westinghouse has sold more than 70% of the Reversing Mill Drives in the United States

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1 60 in. Universal Plate Mill—Bethlehem Steel Co., Sparrows Point, Md.
50 in. Slabbing Mill—Imperial Steel Co., Japan
40 in. Blooming Mill—Bethlehem Steel Co., Lackawanna, N. Y.

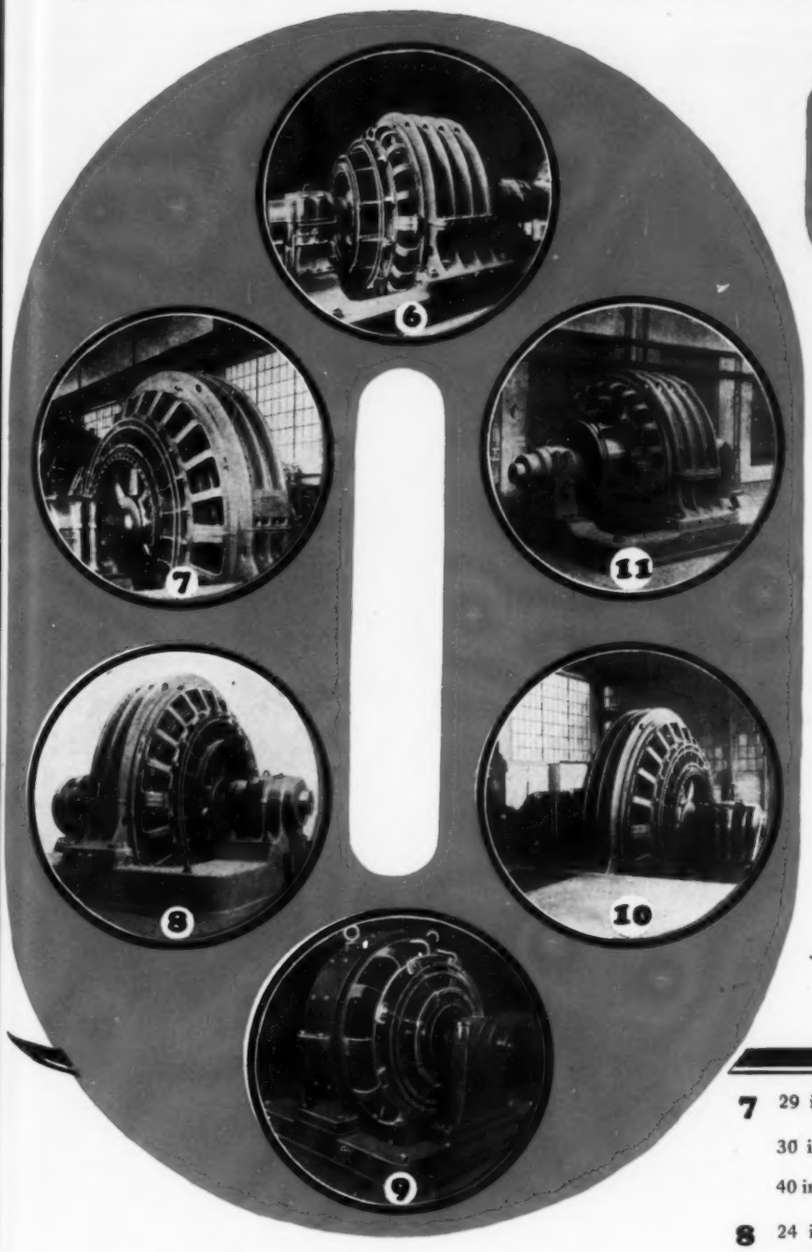
2 44 in. Blooming Mill—Bethlehem Steel Co., Steelton, Pa.
40 in. Blooming Mill—Algoma Steel Co., Sault Ste. Marie, Ont.
40 in. Blooming Mill—Inland Steel Co., Indiana Harbor, Ind.
40 in. Blooming Mill—National Tube Co., Lorain, Ohio
40 in. Blooming Mill—Illinois Steel Co., Gary, Ind.

3 35 in. Blooming Mill—Youngstown Sheet & Tube Co., Mark Works, Indiana Harbor, Ind.
35 in. Blooming Mill—Bethlehem Steel Co., Bethlehem, Pa.
35 in. Blooming Mill—United Alloy Steel Corp., Canton, Ohio
32 in. Blooming Mill—Steel Company of Canada, Hamilton, Ont.
36 in. Universal Plate Mill—Illinois Steel Co., S. Chicago, Ill.

4 40 in. Blooming Mill—Imperial Steel Works, Japan
40 in. Blooming Mill—Cia Siderurgica del Mediterraneo, Sagunto, Spain
36 in. Roughing Mill—Carnegie Steel Co., Homestead, Pa.

5 34 in. Blooming Mill—Tubes de Vincey, Lyons, France
34 in. Blooming Mill—Central Steel Co., Massillon, Ohio
34 in. Blooming Mill—Penn Seaboard Steel Corp., New Castle, Del.

Westinghouse



9%

34 in. Blooming Mill—Sharon Steel Hoop Co., Youngstown, Ohio
34 in. Blooming Mill—Automobiles Berliet, Zennessieux, France
42 in. Universal Plate Mill—Youngstown Sheet & Tube Co., Mark Works, Indiana Harbor, Ind.
28 in. Structural Mill—finishing—Inland Steel Co., Indiana Harbor, Indiana
34 in. Structural Mill—roughing—Inland Steel Co., Indiana Harbor, Indiana
84 in. Sheared Plate Mill—roughing—Brier Hill Steel Co., Youngstown, Ohio

6 28 in. Blooming Mill — Atlantic Steel Co., Atlanta, Georgia

7 29 in. Billet Mill—Youngstown Sheet & Tube Co., Mark Works, Indiana Harbor, Indiana
30 in. Bar Mill—Follansbee Brothers Co., Follansbee, W. Va.
40 in. Universal Plate Mill—Dominion Foundries & Steel Co., Hamilton, Ontario

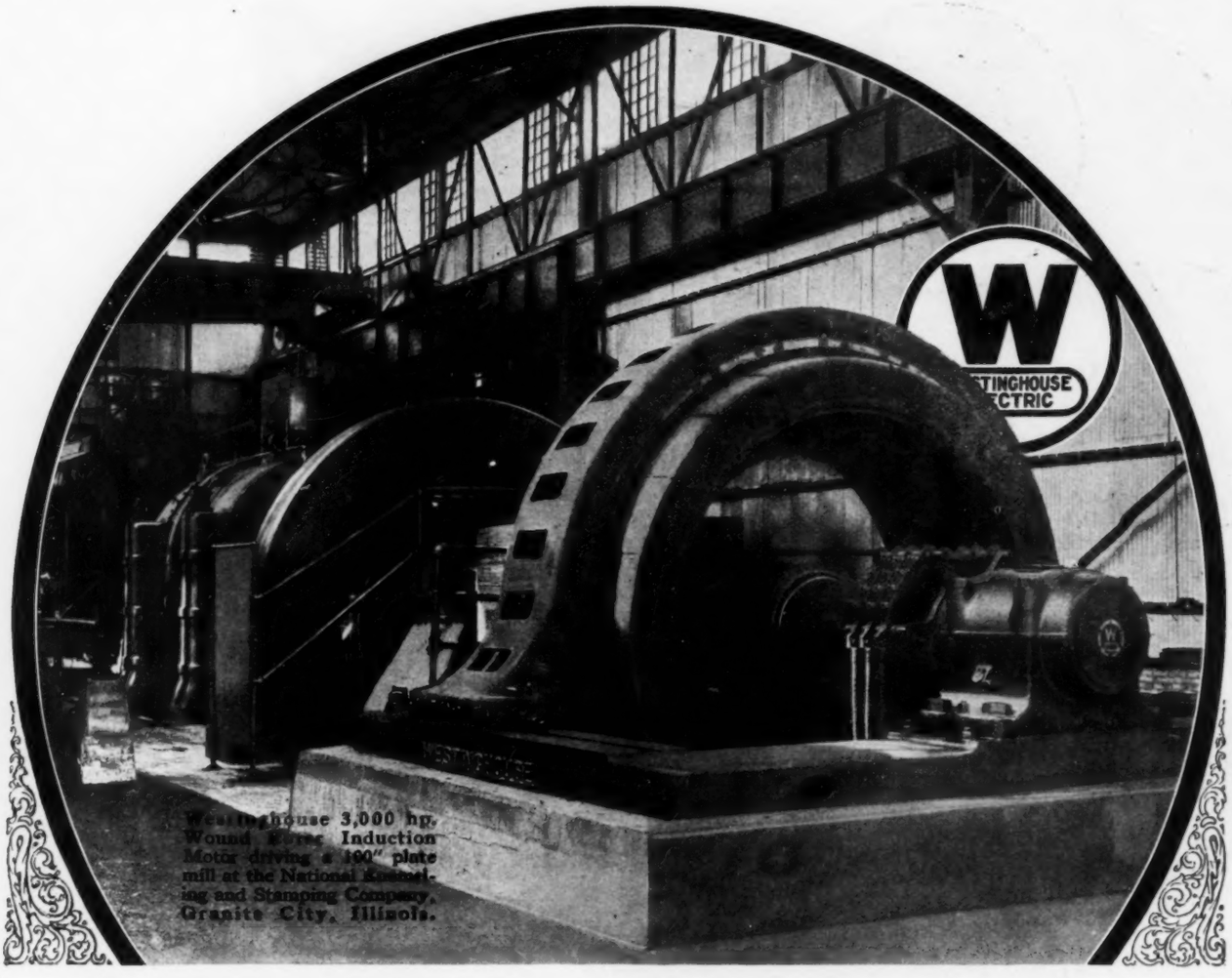
8 24 in. Universal Plate Mill—National Pressed Steel Co., Massillon, Ohio
24 in. Flat Mill—roughing—American Steel & Wire Co., Cleveland, Ohio

9 78" Brass Plate Mill—W. Va. Metal Products Co., Fairmont, W. Va.

10 28 in. Rail Mill—finishing—Algoma Steel Co., Saulte Ste Marie, Ontario
35 in. Rail Mill—roughing—Algoma Steel Co., Saulte Ste Marie, Ontario
48 in. Universal Plate Mill—Bethlehem Steel Co., Lackawanna, N. Y.
24 in. Structural Mill—Cia Siderurgica del Mediterraneo Sagunto, Spain

11 44 in. Blooming Mill—Carnegie Steel Co., Homestead, Pennsylvania

Westinghouse



Westinghouse 3,000 hp. Wound Rotor Induction Motor driving a 160" plate mill at the National Enameling and Stamping Company, Granite City, Illinois.

Advanced Design

THE advanced design of the Westinghouse a-c. Main Roll Drive Motor is characterized by many refinements.

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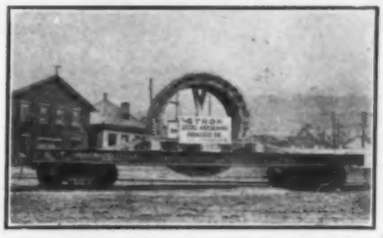
Westinghouse

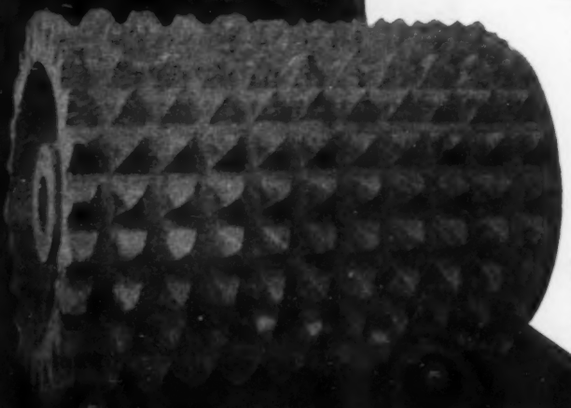
STROH STEEL

BOOTH 55

GREATER SERVICE PER UNIT OF COST GUARANTEED



A Carload of Cement Mill Gears



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Crushers	Hot Shear Knives
Crane Track Wheels	Bending Boxes
Pinions	Cams—Tappets
Coupling Boxes	Wabblers
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Seven years of production—including highest voltage pin and suspension types —without a failure!

There is the reason for use of Lapp Insulators, besides which—for "trimmings" —they provide unexcelled mechanical strength.

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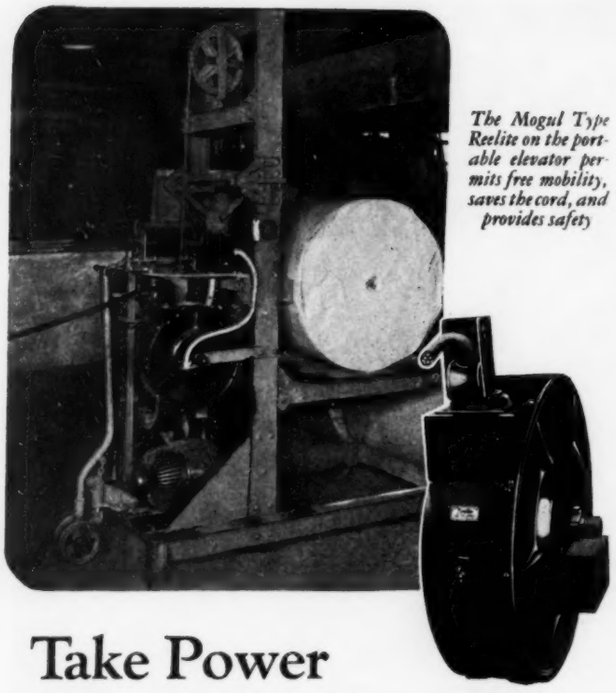
Wetmore-Savage Co.
76 Pearl St., Boston

Jas. J. Niven & Co.
Wellington, New Zealand



The Mogul Type Reelite on the portable elevator permits free mobility, saves the cord, and provides safety

Take Power Where You Need It!

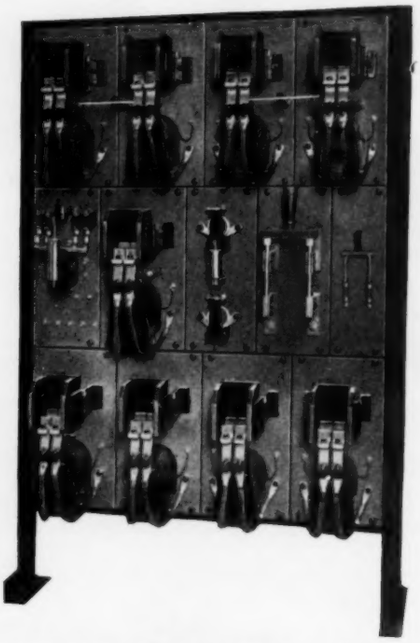
REELITE solves one of the troublesome problems of industry—power for the portable machine. It automatically keeps the cord clean—free from kinks and breaks—out of oil and dust—away from the wheels of trucks and the heels of workmen. It is entirely automatic, paying out and retrieving cord in lengths from 10 to 125 feet depending on the size. Cables of practically any number of conductors can be handled. Let our engineers assist you solve your cord maintenance problems.

Reelites used with portable tools increase plant efficiency

Appleton products for industry include Unilets and the complete line of Appleton Conduit Fittings

APPLETON ELECTRIC COMPANY
1717 *Wellington Avenue - Chicago*

MOGUL TYPE Reelite
REG. U.S. PAT. OFF.



150 H.P. Type 4750 Full Speed Reversing Mill Controller

Automatic Motor Starters and Controllers

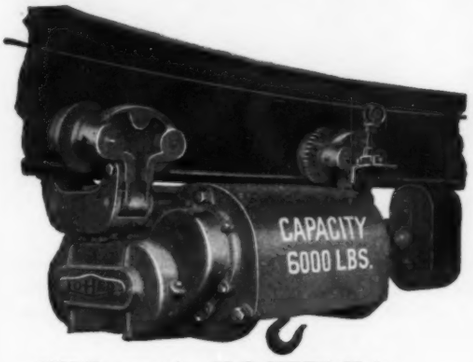
for

Alternating and Direct Current Electric Motors

May we send our nearest representative to see you?

ROWAN CONTROL
THE ROWAN CONTROLLER CO., BALTIMORE, MD.

Don't miss this chance to see the "Lo-Hed"



6000-lb. capacity "LO-HED" Hoist
Motor Driven Trolley, Floor Operated

The newest and most talked about hoist on the market

" The Electric Hoist
that operates
in the
Minimum Headroom "

AT THE IRON AND STEEL EXPOSITION

Duquesne Garden, Pittsburgh, September 15-20

BOOTH 150---Material Handling Headquarters

American Engineering Company, Philadelphia

W. E. FINISH SALAMANDER

magnet wire is particularly adapted for rewinding field and armature coils, solenoids, etc., and is used extensively in the steel industry. It is acid-proof, moisture-proof, oil-proof, heat-resisting and has an extremely tough, smooth, hard finish.

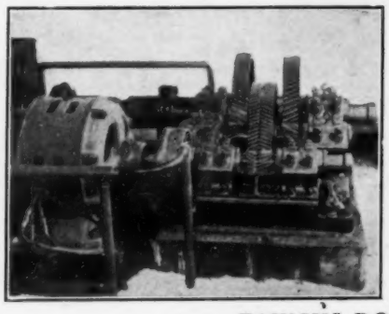
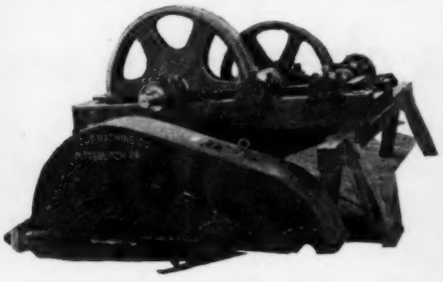
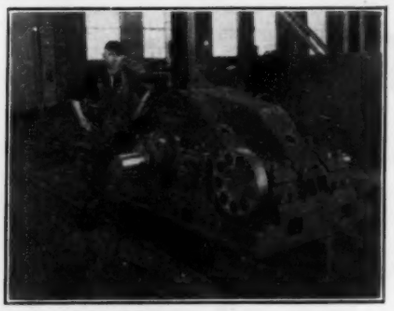
For further information write to our nearest representative for Salamander wires and cables—

Birmingham, Ala. .. W. H. Beaven
Boston, Mass. ..... Wetmore-Savage Company, 74 Pearl Street
Chicago, Ill. ..... J. D. A. Cross, 213 S. Peoria Street
Cleveland, Ohio ... H. Lee Reynolds Company, 309 Plymouth Building
Denver, Colo. ..... Franklin Sales Company, Denham Building.
Los Angeles, Cal. .. A. S. Lindstrom, 1144 Maple Avenue
Philadelphia, Pa. ..... F. K. Simons Electric Co., Fuller Building
Pittsburgh, Pa. ..... H. Lee Reynolds Company, Oliver Building.
Portland, Ore. ..... A. S. Lindstrom, 312 McKay Building
Salt Lake City, Utah .. Raymond Ackerman, 419 Dooly Building
San Francisco, Cal. ..... A. S. Lindstrom, 111 New Montgomery Street
Seattle, Wash. ..... A. S. Lindstrom, 95 Connecticut Street

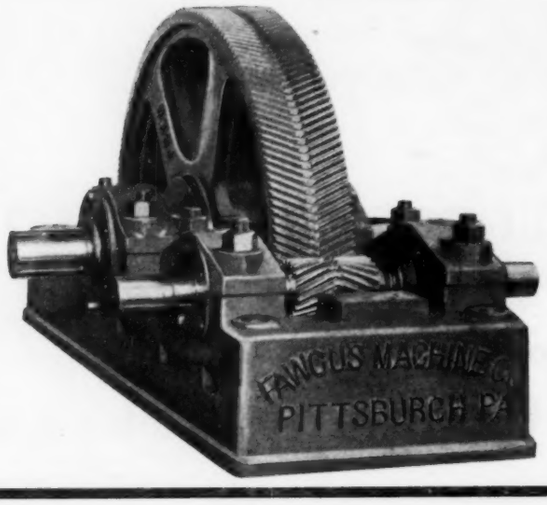
YORK INSULATED WIRE WORKS

of General Electric Company

Works: York, Pa. Office: 1737 Broadway, N. Y. C.

FAWCUS DOUBLE REDUCTION HERRINGBONE GEAR DRIVES



Herringbone Gear Single and Double Reduction Drives. Used for Steel, Brass and Rubber Rolling Mill Electric Drives, Electric Driven Pumps, Hoist, Elevators, Conveyors, Paper Machinery, etc.

Fawcus Cut Herringbone Gears, Spurs, Worms, Bevels, Flexible Couplings and Special Machinery.

Fawcus Machine Co.

PITTSBURGH, PA.

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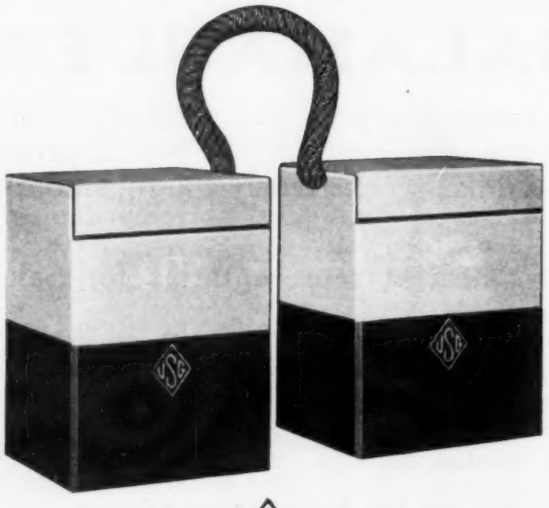

USG

on every brush

Dinkey Controller Contacts

Manufactured from a fine, dense, hard, carbon-graphite composition which insures you against pitting, chipping or breaking in operation and assures you of extremely long life with a minimum of care and attention. Once U.S.G. Contacts are applied, the changing of contacts becomes a rarity.

All U.S.G. Controller Contacts and Brushes are especially designed for the service intended.

Write for Catalog B-3 for complete details of the characteristics of the various grades of U.S.G. Carbon, Graphite, and Metal-graphite Products.

THE UNITED STATES GRAPHITE COMPANY

Saginaw, Michigan, U. S. A.

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Electrical Engineering & Mfg. Company

General Offices:
Pittsburgh, Pennsylvania

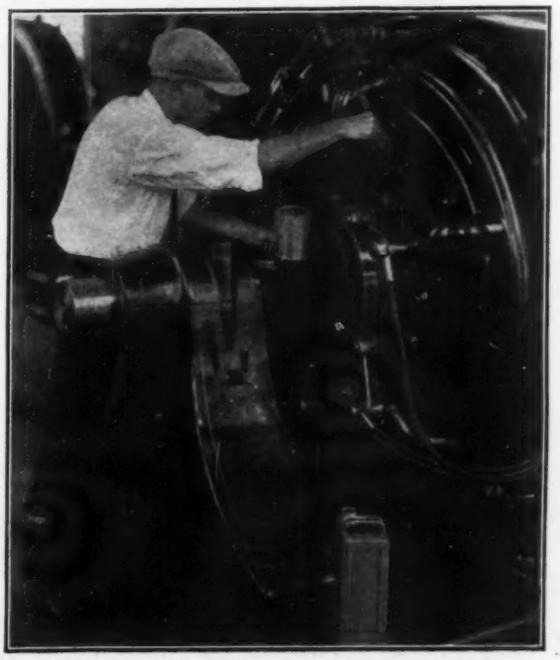
Announcement

We have now completed a Decade of service to the Industrial Railway and Light Trade in our territory. During this period we have tried earnestly and persistently to give our patrons the very best materials, equipment and service that we could command for them, and to fully merit their confidence and respect. In this we have apparently succeeded to a gratifying degree. We, therefore, wish to use this occasion to thank our patrons and friends for the opportunities they have given us of co-operating with them and to express the hope that we may be able to make ourselves even more useful to them in the future.

J. P. Hutcheson, Branch Manager,
320 Union Building
Cleveland, Ohio

A. A. Morton, Branch Manager,
606 Mercantile Library Bldg.
Cincinnati, Ohio

Imperial Armature Washing Fluid



NON-COMBUSTIBLE—NON-CONDUCTING

For cleaning grease and dirt from Armatures, Field Coils, Brushholders, Meter windings, Fans and other places.

Send in coupon for circular describing this new product

Use "Imperial" Commutator Stones

Reason No. 7: They save from 75% to 95% of the cost of turning the commutator.
Another advantage will be given next month.
2933 users on August 1st, a gain of 93 for July.

Write for information.

We can supply you with

Commutator Grinders
Slotting Files
Slotting Machines
Commutator Cement
Insulating Beads
Insulating Varnish
Gauze Wire Brushes
Portable Blowers

The Martindale Electric Company,
11729 Detroit Ave., Cleveland, Ohio.

Gentlemen:
Please send me circular describing Imperial Armature Washing Fluid.

Name .....
Firm .....
(Please print)
Address .....
City ..... State .....

Nahango

A kaffir kid, when he loses his first teeth, must throw them on top of the hut with a plea to the invisible grandmother to exchange them for her harder and more durable teeth.

The first were unsatisfactory—hence the nahango (changing teeth).

And on this side of the planet you see an operator throw some ill-chosen carbon brushes on the maker, saying, "These brushes wore out too fast, send us some that are more durable." And the old grandmother sends some harder ones.

Later he has to write to the motor people, saying, "These commutators wore out too fast, send us some that are more durable."

Funny, isn't it, how people will fool around with slapstick methods, forgetting that Morganite brush engineers figure out brush applications with slipstick accuracy.

MORGANITE BRUSH CO., INC.
519 West 38th St., New York City
DISTRICT ENGINEERS AND AGENTS

Morganite

Electric Power Equipment Corp., 412-420 North 18th St., Philadelphia, Pa.

O. T. Hall, Sales Engineer, 1926 Edmonson Ave., Baltimore, Md.

Electrical Engineering & Mfg. Co., 909 Penn Ave., Pittsburgh, Pa.

Electrical Engineerng & Mfg. Co., 422 Union Bldg., Cleveland, Ohio.

Special Service Sales Co., 502 Delta Bldg., Los Angeles, Calif.

J. F. Drummey, 75 Pleasant St., Revere, Mass.

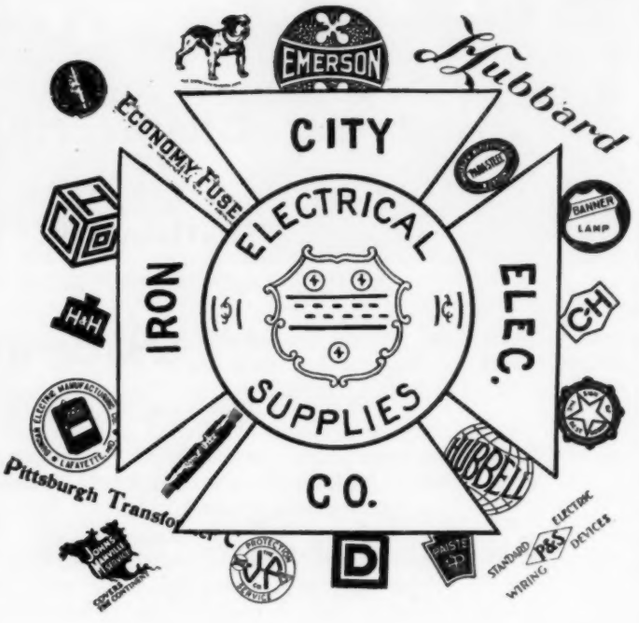
Special Service Sales Co., 202 Russ Bldg., San Francisco, Calif.

Electrical Engineering & Mfg. Co., 607 Mercantile Library Bldg., Cincinnati, Ohio.

Railway & Power Engineering Corp., Ltd., 131 Eastern Ave., Toronto, Ontario, Canada.

Railway & Power Engineering Corp., Ltd., 326 Craig St., West, Montreal, Canada

Railway & Power Engineering Corp., Ltd., P. O. Box No. 325, Winnipeg, Canada



The Trade Mark

of the

Iron City Electric Co.

436-38 Seventh Avenue

Pittsburgh, Pa.

REPRESENTING

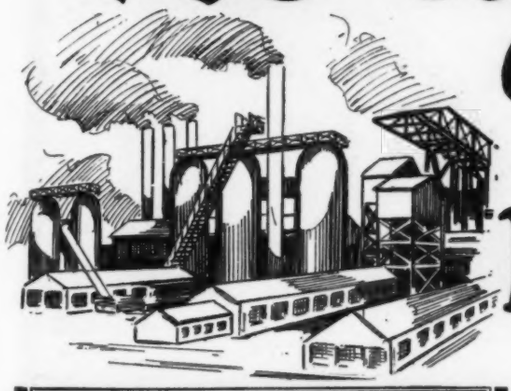
"The House That Service Built"

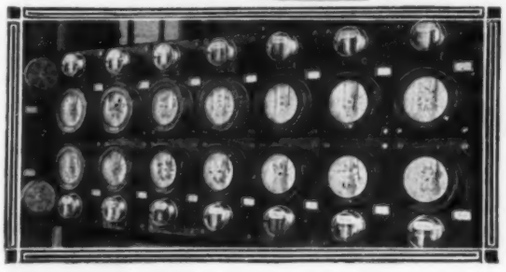
IS BACKED BY A GROUP OF

TRADE MARKS

of Well Known Manufacturers Guaranteeing the Quality of the Goods You Receive

126 Steel Plants Cut Steam Cost with Republic Meters





Illustrating the value of the Republic Flow Meter in the steel industry is this statement by Mr. M. M. Argo, Power Plant Engineer, Sloss-Sheffield Steel & Iron Company, Birmingham, Ala.:

"The effect of the flow meters on fuel consumption is shown by the boiler performance on a few occasions when one or more meters have been disconnected. In such instances, the distribution of load was necessarily a matter of guesswork, and as a result the boilers were seldom operated at their most efficient loads. **Our average efficiency, using the meters, is about 75%, but when the meters are not used, this drops to approximately 65%.**"

"The integrating meters are read at 6 A. M. every day, and the 24-hour efficiency of each boiler is calculated. When these daily records show that the efficiency of a particular boiler is falling below normal, it serves as a warning that something needs attention. By finding the fault and correcting it, we save fuel."

"The saving, reduced to a coal basis, amounts to approximately 4 tons of coal a day for each boiler. Since 7 boilers are usually run at a time, **the net annual saving is $22,431.44. This is a yearly return of 701% on the investment** of $3,200.00 in these meters."

Let us show you how you can obtain

1—Central control through electrical operation.
2—Operating horsepower of boiler at a glance by which over and under loading the boilers is eliminated.
3—Accurate records of steam flow.
4—Total pounds of steam generated, and thus cost per thousand pounds.

Write for bulletins, S-6 on measurement of steam, CA-6 on power plant cost accounting and OC-6 on operation and construction of Republic Flow Meters.

A few of the Steel Companies Republic equipped:

All waste heat boilers completely equipped with Republic Meters. Gas Meters on 8-foot gas line and distributing line.

Illinois Steel Co.—85 Meters.
Wisconsin Steel Co.—53 Meters.
McKeesport Tin Plate Co.—27 Meters.
Tennessee Coal, Iron & R. R. Co.—42 Meters.
Youngstown Sheet & Tube Co.—63 Meters.
Steel & Tube Co. of America—27 Meters.
American Steel & Wire Co.—34 Meters.
Bethlehem Steel Co., Carnegie Steel Co.,
Charcoal Iron Co. of America, Chase Rolling Mills,
Colorado Fuel & Iron Co., United Alloy Steel Corp.,
Dominion Iron & Steel Co., Gulf State Steel Co.,
Jones & Laughlin Steel Co., Kobe Steel Works,
Lukens Steel Co., Minnesota Steel Co., National Tube Co.

MANUFACTURERS OF:

Flow Meters, Steam, Air, Gas, Water Meters, CO_2 Recorders, Coal Meters, Draft Indicators and Recorders, Manometers, Model SFC Steam Flow and CO_2 Pyrometerss

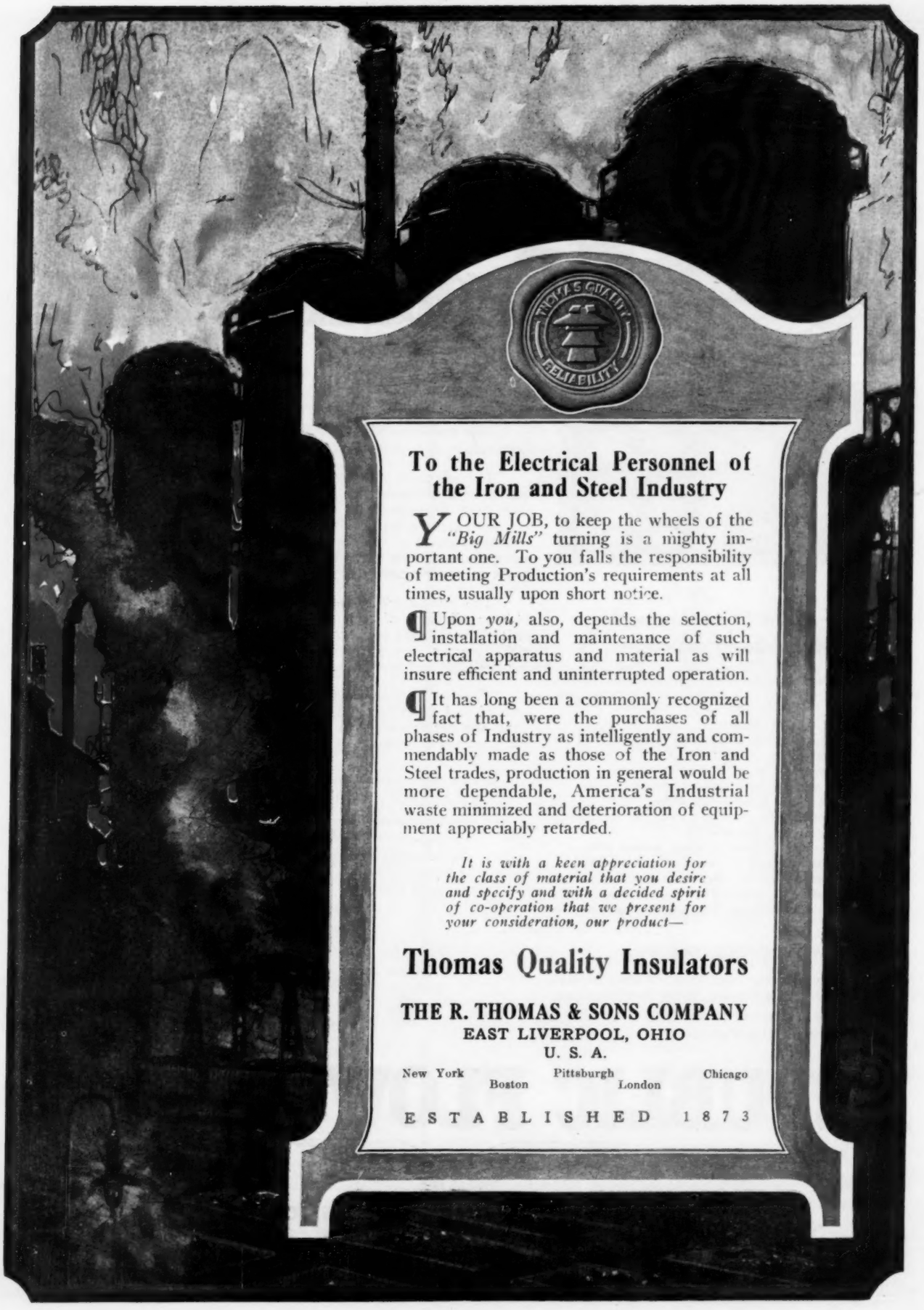
REPUBLIC FLOW METERS

Dominion Flow Meters Co., Toronto, Canada

Electro Flow Meters Co., 109 Kingsway, London, W. C. 2

Republic Flow Meters Company
2222 Diversey Parkway Chicago, Illinois

BRANCHES IN ALL PRINCIPLE CITIES



To the Electrical Personnel of the Iron and Steel Industry

YOUR JOB, to keep the wheels of the *"Big Mills"* turning is a mighty important one. To you falls the responsibility of meeting Production's requirements at all times, usually upon short notice.

¶ Upon *you,* also, depends the selection, installation and maintenance of such electrical apparatus and material as will insure efficient and uninterrupted operation.

¶ It has long been a commonly recognized fact that, were the purchases of all phases of Industry as intelligently and commendably made as those of the Iron and Steel trades, production in general would be more dependable, America's Industrial waste minimized and deterioration of equipment appreciably retarded.

It is with a keen appreciation for the class of material that you desire and specify and with a decided spirit of co-operation that we present for your consideration, our product—

Thomas Quality Insulators

THE R. THOMAS & SONS COMPANY
EAST LIVERPOOL, OHIO
U. S. A.

New York Boston Pittsburgh London Chicago

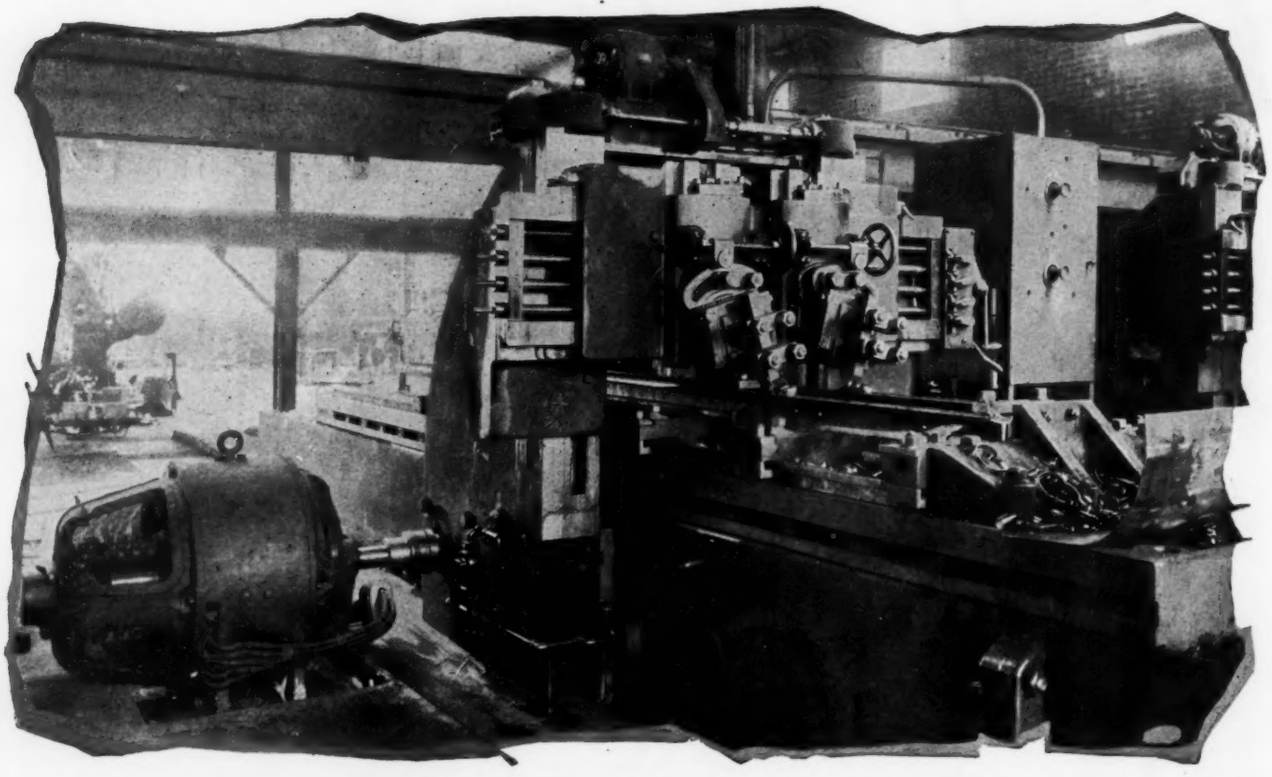
ESTABLISHED 1873

It's all in the Bond—

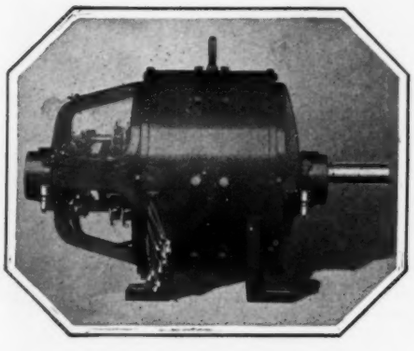
THIS WAY, that way, this way, that way—is the eternal story of the reversing mill or crane motor. What a lot of severe electrical and physical punishment the brushes must endure. When the component materials of the brushes are firmly bonded the wear and tear is minimized. The bond used in CORLISS GRADE C brushes produces a material which resists disintegration under the most extreme conditions.

CORLISS CARBON COMPANY
BRADFORD, PENNA.

CORLISS BRUSHES



Gray Frog and Switch Planer driven by 50 h.p., 250-1000 r.p.m. Type T. Heavy Duty Reliance Reversing Planer Motor.



Type T Reversing Planer Motors have been in successful operation for six years on planers of all makes, doing hard jobs in locomotive shops, steel mills, ship yards, frog and switch shops and machine tool plants.

Big chips drop fast, here

Frog and switch shops are machining steel rails on these machines at a production rate that could be maintained only with motor drive. The ability to stand the pace set by such rugged machines entitles Type T Reliance Motors to be termed "Heavy Duty."

Reversing motor drive on frog and switch planers provides a positive drive with ample power for heavy cuts, the elimination of belt troubles, accurate adjustment of cutting speeds over a 1:2 range, and separate adjustments for return strokes.

Detailed information regarding reversing motor drive for planers is given in our new Bulletin 2016. It's interesting and contains 28 illustrations. We shall be glad to send it.

Reliance Electric & Engineering Company

1080 Ivanhoe Road, Cleveland, Ohio

Branches: Boston New York Philadelphia Pittsburgh Cincinnati Detroit Chicago Birmingham, Ala.

Type T Heavy Duty RELIANCE MOTORS Direct Current

Now is the time to prepare for the party!

THE United States Steel Corporation is spending between $80,000,000 and $90,000,000 for equipment to lower costs. It is one of many corporations who are getting their "houses in order" for big business. They realize that now is the time to prepare for the party.

They know, as every wise business executive knows, that when the new immigration law begins to exercise its full influence, only 150,000 immigrants yearly can be drawn upon for labor instead of 1,500,000, as heretofore. And this new law affects more the countries that supplied most of our unskilled labor than it does those countries which furnished the skilled workmen.

In most every line of commercial and industrial activity lifting and load-moving are big factors in the cost of production and distribution—the jobs that in many businesses now rest with unskilled labor.

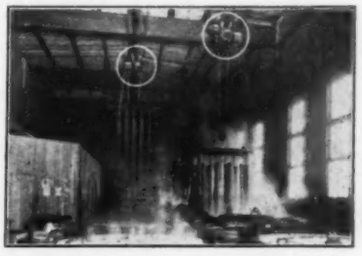
Thousands of business executives carry on their lifting and load-moving at rock bottom cost—they use Shepard Electric Hoists.

These hoists are made in capacities of ¼ ton to 10 tons and are operating in great numbers in practically every known business and industry.

The Shepard Electric Crane & Hoist Company can show you actual dollars and cents savings on every type of Shepard hoist in service. Shepard hoists will save for you. The four general types are shown herewith. Write for information today.

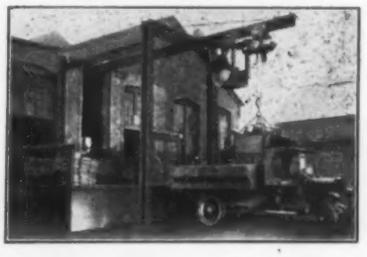
SHEPARD ELECTRIC CRANE & HOIST CO.
376 Schuyler Ave., Montour Falls, N. Y.
Branches in Principle Cities
Member Electric Hoist Mfrs.' Assn.
2532-8

THIS hoist is made in ½ and 1 ton capacities. Produced on a quantity production basis, it is exceptionally low in price for the Shepard quality built into it. The Lift-About "Book of Illustrated Economies" depicts and describes over 60 ways by which it is saving money in many and varied lines. Send for it.



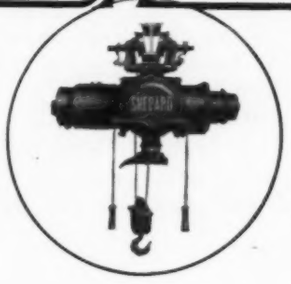
THIS is the standard line of Shepard hoists in capacities to 10 tons. Made in types for application in hundreds of ways. They, **like all Shepard equipment,** are dust-, damp-, dirt-, and fume-proof throughout.

With the wide range of hoists which we can supply in this group, and the others, every type of business may have economical load handling machinery.



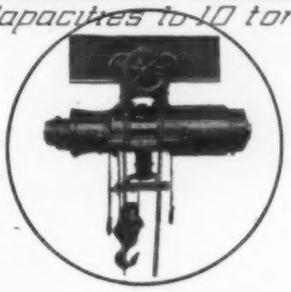
SHEPARD Cage Operated Electric Hoists are controlled by a man who rides in the traveling cage. An extensive overhead track system may be laid out to carry loads between departments and buildings, thereby reducing handling costs to the minimum. Capacities to 10 tons.

THE SHEPARD ELECTRIC LIFT ABOUT



ELECTRIC HOISTS
Cage Operated

ELECTRIC HOISTS
Capacities to 10 tons



REG. U.S. PAT. OFF.

SHEPARD
ELECTRIC CRANES & HOISTS

Pittsburgh Transformers *for* Electric Steel Furnaces

4500 Kva. Pittsburgh Polyphase Furnace Transformer
built for
United Alloys Steel Corporation

When you have the specifications ready for your next order for transformers, let us submit proposal on Pittsburgh Transformers.

Pittsburgh Transformer Company

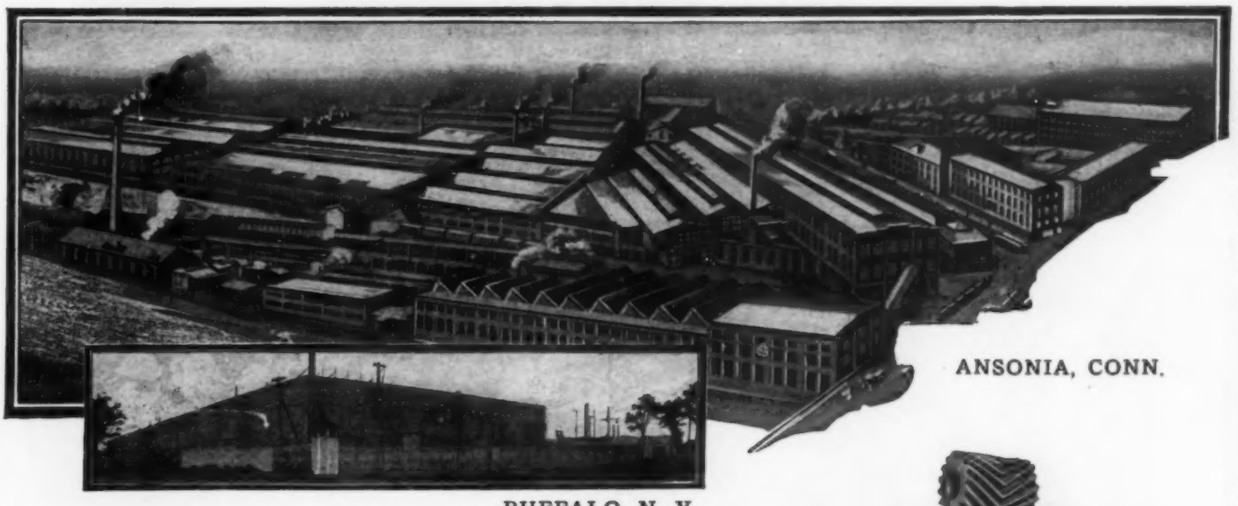
Largest Manufacturers of Transformers Exclusively in the United States

Pittsburgh, Pennsylvania

FARREL
SYKES GEARS

Visit Our Booth at the
IRON & STEEL EXPOSITION
Duquesne Garden
PITTSBURGH, PA.
September 15th to 20th, 1924

Where Sykes Herringbone Gears are Made



ANSONIA, CONN.

BUFFALO, N. Y.

Founded in 1848, the FARREL FOUNDRY & MACHINE COMPANY has grown to rank among the foremost engineering firms in the country. The two plants, one at Buffalo and the other at Ansonia, have a total of 450,000 square feet of floor space and forty acres of land for expansion.

As the foremost builders of chilled iron rolls, the FARREL FOUNDRY & MACHINE COMPANY is well known to all, in the paper, textile, rubber, paint, chocolate, grain and non-ferrous metal industries.

FARREL FOUNDRY & MACHINE COMPANY have always been the leaders in the manufacturing of machinery for the rubber, sugar, linoleum, non-ferrous metal and other industries. For many years for use on the machinery we have built, we have turned out hundreds of cut herringbone gears and enclosed reduction units. The latest and best machine tools are in our shops. In our organization is a competent and experienced engineering force.

Upon this substantial foundation is built our SYKES herringbone gear business.

When ordering gears, remember that there is no finer gear in the country today than the SYKES herringbone gear.

THE GEAR WITH A BACKBONE

Farrel Foundry & Machine Company

BUFFALO, N. Y.—U. S. A.

NEW YORK CITY
BOSTON, MASS.
CLEVELAND, OHIO
LOS ANGELES, CAL.
SAN FRANCISCO, CAL.
HAVANA, CUBA

BUFFALO, N. Y. ANSONIA, CONN.

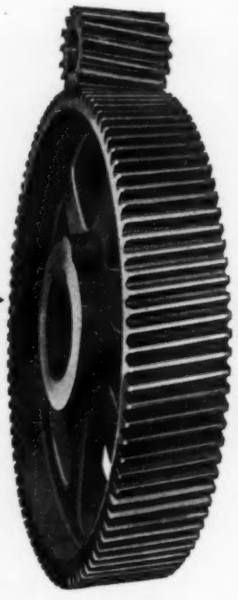
Isn't That a Dandy Looking Flexible Coupling?

That's a Nuttall Type C—Safety first, entirely enclosed, spring buffers, good for 85 to 2700 H.P., 440 to 3600 r.p.m.—1½" to 15"½ shafts, outside diameters 6½" to 52". May we send you booklet describing our couplings in detail? We make two other types.

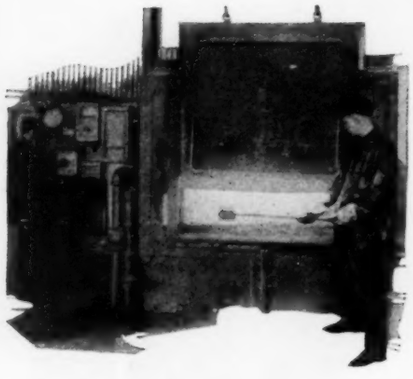
Did you ever hear a quiet street car?

Just listen when some of Pittsburgh's new yellow Crosstowns pass, but don't stand on the track without looking—they sure do slip up on you. Any machine, crane or motor in your plant can be made just as quiet—here's how →

Complete literature or an engineer at your service without obligation.



Helicals
—the Gears that made Nuttall famous.



Just as brass and iron superseded wood and stone—just as steel superseded iron, heat treated steel has superseded ordinary steel, and the Nuttall heat treating plant has turned out some of the most exacting work in the world; oil, gas and electric furnaces, pyrometers, Brinell and Shore testing machines, water, brine, oil, chemical and BP quenching tanks. It's a wonderful plant and you ought to see it while you are in town.

R.D. NUTTALL COMPANY
PITTSBURGH PENNSYLVANIA

Philadelphia Office
420 Land Title Bldg.

Chicago Office
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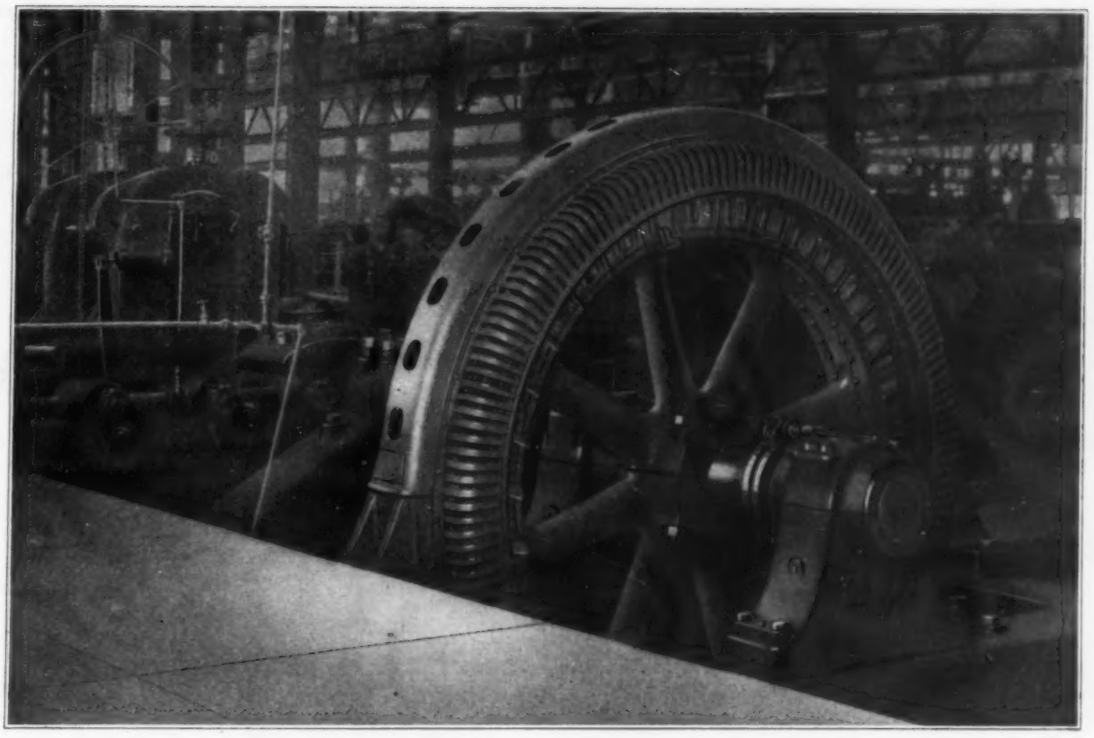
Nuttall

ALLIS-CHALMERS



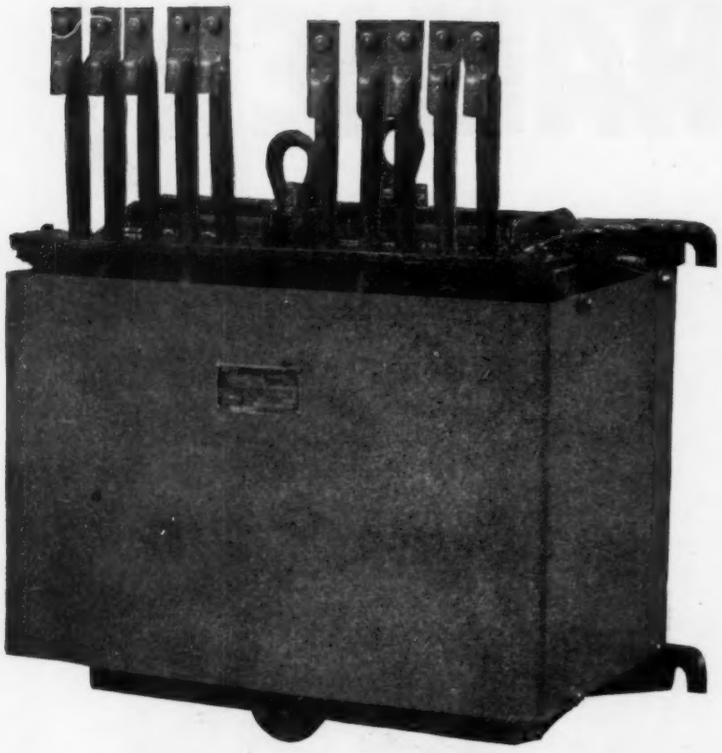
Synchronous Motor Rolling Mill Drive

800 H.P., 109 R.P.M., 2200 V., 3 Ph., 60 Cy., Mill Type Synchronous Motor, driving two stands of 21″ rolls. This Mill Type Synchronous Motor, coupled directly to the mill without the use of a clutch, has been entirely successful.

ALLIS-CHALMERS PRODUCTS
Electrical Machinery
Steam Turbines
Steam Engines
Gas and Oil Engines
Hydraulic Turbines
Crushing and Cement Machinery
Mining Machinery

ALLIS-CHALMERS MANUFACTURING COMPANY
MILWAUKEE, WISCONSIN, U.S.A.
District Offices in All Leading Cities.

ALLIS-CHALMERS PRODUCTS
Flour and Saw Mill Machinery
Power Transmission Machinery
Pumping Engines-Centrifugal Pumps
Steam and Electric Hoists
Air Compressors - Air Brakes
Agricultural Machinery
Condensers



Packard

MOTOR STARTING COMPENSATORS

On Display Booth 60-61 Iron and Steel Exposition

Of the two coil type. Three phase or two phase. Made for either 25 or 60 cycle and for any size motor.

Each terminal is provided with duplicate lugs, making installation a simple matter.

The unit is ruggedly mounted between heavy cast iron end plates, held in place by duplicate tie rods, which provide means for convenient lifting.

Heavy slotted feet are provided to facilitate installing on either floor or wall (the unit can be lowered into position after the bolts are in place).

Heavy copper windings are used with double cotton covered insulation and ample spacing between layers is provided to enable the unit to stand repeated starting service and severe abuse, such as is frequently encountered in the iron and steel industry.

A neat sheet steel housing of ample proportions is firmly clamped around the entire coil section, without interferring with ventilations, so that the coils are protected from mechanical injury.

The large number of Packard Motor Starting Compensators giving perfect service after years of operation attest to the fact that they are one of the most rugged, reliable and dependable starters available for industrial purposes.

The Packard Electric Company

WARREN, OHIO

Transformer Manufacturers since 1890

AIR!

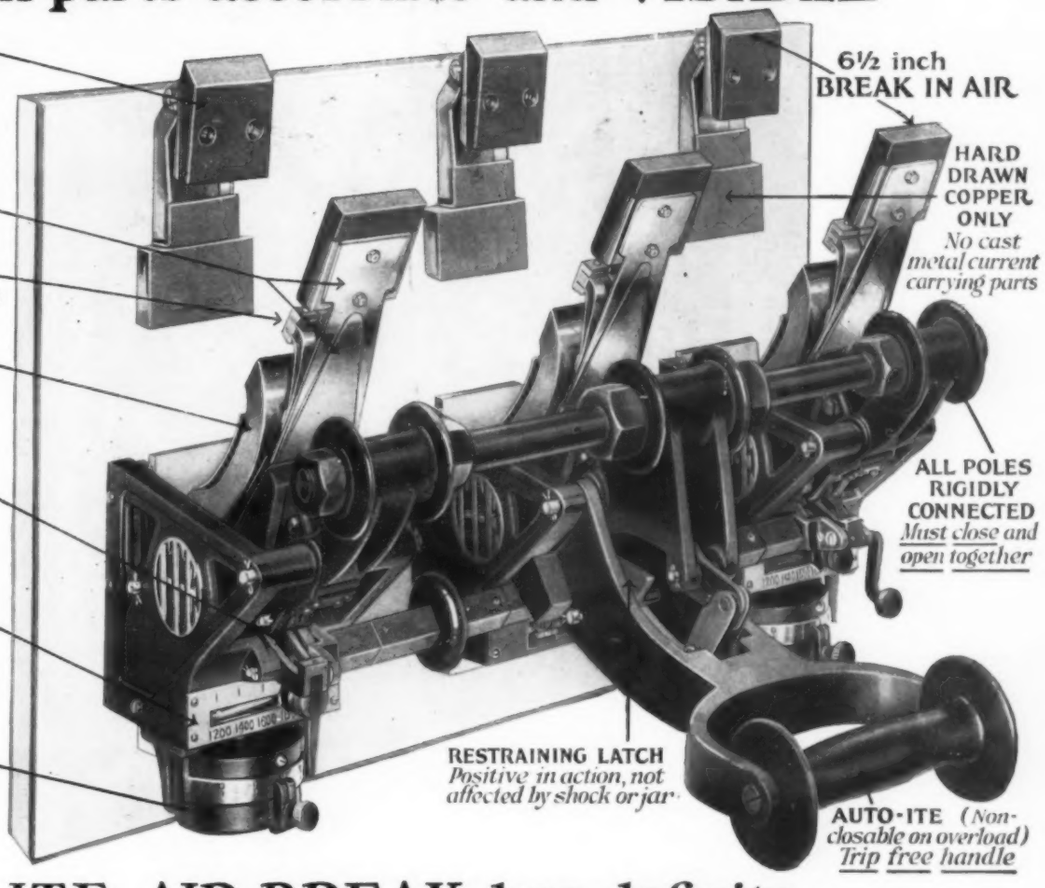
I-T-E CIRCUIT BREAKERS

For Alternating Current

600 VOLTS OR LESS

Give protection without complication

All parts accessible and VISIBLE


COPPER JACKETED PRESSURE CARBONS
For initial contact and final break
Mechanically strong
Electrically perfect
PHOSPHOR BRONZE CARBON SUPPORTS
HEAVY METALLIC SECONDARY BREAKING CONTACTS
LAMINATED BRIDGE
Each leaf individually formed - Heavy even pressure on every Lamination
CLOSING TOGGLES
Afford heavy contact pressure with easy closing
OVERLOAD
Direct acting. Long scale calibration. No relays or series transformers
DALITE
(Direct acting time limit) feature. Adjustable from zero to maximum time. No relays
6½ inch BREAK IN AIR
HARD DRAWN COPPER ONLY
No cast metal current carrying parts
ALL POLES RIGIDLY CONNECTED
Must close and open together
RESTRAINING LATCH
Positive in action, not affected by shock or jar
AUTO-ITE (Non-closable on overload)
Trip free handle

I-T-E AIR BREAK has definite advantages not present in the oil breaker

1. *No oil — to leak, carbonize, burn or explode — Just air.*
2. *No tanks to conceal anything — or the lack of it.*
3. *No cells — nothing which needs or deserves to be imprisoned — Just a faithful and efficient servant.*
4. *Inherent simplicity — with resulting low cost of installation and maintenance.*

The CUTTER COMPANY

ESTABLISHED 1888 PHILADELPHIA

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General Electric invites you to inspect its exhibits at Duquesne Garden, Spaces 120-129.

There you will find a friendly, helpful and complete service to meet your needs for whatever electric equipment you may require.

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